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AGRICULTURAL ENGINEERING

The Journal of Engineering as Applied to Agriculture

RAYMOND OLNEY, Editor

Vol. 7 MARCH, 1926 No. 3

EDITORIALS

Engineering Agriculture

IT IS only within recent years that we have come, to any extent, to associate engineering with agriculture. Now we know that there is a very definite and very close relationship between the two. And considering that it is a comparatively recent development, agricultural engineering today is remarkably well established as an important and necessary branch of agriculture and as a well-defined division of engineering.

Agricultural engineering has been classified as one of the industrial branches of engineering. That is, it is the application of civil, mechanical, and electrical engineering—what we may call the fundamental branches—to a particular industry, the agricultural industry. The agricultural engineer, therefore, may be defined as an engineer with an engineering training and an agricultural background. His job is to solve the engineering problems peculiar to the agricultural industry. And if there is no justification for agricultural engineering, then there is no justification for the old-established profession of mining engineering, or highway engineering, automotive engineering, or any of the other industrial branches of engineering. As a matter of fact, however, the day is past when there is need to defend agricultural engineering in well-informed circles.

The American Society of Agricultural Engineers was organized but eighteen years ago by a handful of men who had not a little difficulty in deciding what they ought to call themselves, but they very fittingly chose to call themselves "agricultural engineers." Considering its comparatively recent origin, as such, the agricultural-engineering profession has had what is truly a remarkable growth during the period since December 1907, but as in probably all branches of science and engineering, that growth has been largely by force of necessity. The need of modern engineering science to meet agricultural requirements is apparent on every hand. When one attempts to anaylze the present needs of agriculture and to comprehend the engineering problems pressing for attention, the result is amazing. We are just beginning to wake up to the many, many tasks awaiting the agricultural engineer.

Why is agriculture so much in the limelight these days? Something must be the matter with it or it wouldn't be receiving so much attention.

It is generally recognized that this country has progressed far more rapidly industrially than it has agriculturally. The reason for this is that the more rapid growth of industry is due to the fact that its development has been largely along engineering lines. We have been slow in applying engineering to agriculture and, therefore, agriculture has lagged. The following quotation hits the nail squarely on the head: "It is a lack of proper engineering more than anything else that has brought about the difficulties that now beset agriculture. And until sound engineering is applied these troubles must continue. It cannot escape competition with industry. It cannot well compete with engineered industry until it also is engineered along sound, modern lines."

The problem of developing a truly engineered agriculture—an agriculture that can compete with industry because engineered—is the problem of the agricultural engineer—not the agricultural engineer working alone but in the closest possible cooperaiton with other groups of engineers, agricultural scientists, farmers, and others. Agricultural engineering is not a panacea for the ills of agriculture, but a most important link in the chain, although no doubt the weakest at the present time. And that is no reflection on the agricultural engineer.

There is another important angle to this problem of putting agriculture on a par with industry that we must not forget. We will find it impossible to do it so long as agriculture is carried on in small independently owned and operated units as it is today. As agricultural engineers we must recognize that in order for agriculture to compete with industry—to get production costs down to where they ought to be—the present size of our farm units must be increased ten times—yes, even one hundred times where conditions are favorable. I see no reason why we should not look for large corporate enterprises in agriculture just as we now have them in manufacturing.

I do not believe the small farm will ever be a thing of the past. We will always have small farms just as we have small manufacturing establishments. I do contend, however, that the day is coming when the great bulk of agricultural production in this country will be from the large farms, the sixteen-hundred and the sixteen-thousand-acre farms rather than from the one-hundred-and-sixty-acre farms.

I look for just as remarkable, just as far-reaching developments in agriculture as we have witnessed in the fields of manufacturing and transportation, for example, as a result of engineering development and particularly through the application of mechanical power.

We are at the dawn of a new era in agriculture, an era when the engineer will be an outstanding figure in its development.

RAYMOND OLNEY

(NOTE: The foregoing is from an address at the dedication of Ives Hall, Ohio State University, February 3, 1926.)

Advertise Your Society

THE following statement from a popular farm magazine is very significant: "The revivals don't make for stickers in anything, whether it's religion or agriculture, etc." The author, himself an experienced organizer, continued by citing a long list of instances where agricultural organizations had been created and expanded to large proportions almost over night only to fall apart long before serving their purpose.

Fortunately most of the members of the American Society of Agricultural Engineers are "stickers." As long as that fact remains the growth of the Society will take care of itself, provided as members our efforts to increase membership are directed in one necessary direction, that is, to educate the public to what we stand for. In other words, advertise.

It takes a good article to stay on the market today without keeping up a flow of publicity about it. Not long ago a rich cough medicine manufacturer died leaving the business in the hands of his wife with the help of his former advisers. The latter decided to cut out about a third of the overhead expense of the business by reducing on the elaborate advertising expenditures. Before the first year was over the company was losing money for the first time. A new effort was made in advertising but it was too late. Apparently the quality of the product will keep the old "stickers," but it takes advertising to get new customers.

How are we going to advertise? As an organization we are already doing much. It remains then for us as individuals to talk agricultural engineering and A.S.A.E. to our friends and coworkers, and from there it will spread. Nothing is quite as good advertising as the evidence of an enthusiastic individual membership.

D. B. LUCAS

A Study of Factors Involved in Ensilage Cutter Design *

By F. W. Duffee

Assoc. Mem. A.S.A.E. Associate Professor of Agricultural Engineering, University of Wisconsin

THE investigations of ensilage cutters at the University of Wisconsin during the fall of 1925 followed up some of those begun in 1924 and covered some new ones. This year's work includes the following studies:

1. Practicability of the four-knife flywheel machine
2. Some features controlling efficient elevation, including a new theory on discharge housing design
3. Proper ratio of feed table travel to feed roll speed
4. Comparative performance of four and six-blade fans on a cylinder machine
5. Clearance in fan housing at various points
6. Standardization of size rating
7. Standardization of pipe connections
8. Reducing speed for efficiency

Practicability of the Four-Knife Flywheel Machine. The investigations of last year brought out very forcibly the desirability of reducing the speed in the interest of lighter running. In one particular test, reducing the speed of a 15-inch flywheel machine from 700 to 350 r.p.m., cut the total power to one-seventh and the power per ton to one-third. A summary of the investigations along this line indicated (1) that a 14 or 15-inch flywheel machine should be run much slower than now commonly recommended, if low power requirements are desired; (2) that a properly designed machine will elevate successfully and cut satisfactorily at the slower speeds and naturally with much less wear and tear, and (3) that the machines as now built will not satisfy the farmer as to capacity.

We therefore suggested the desirability of developing the four-knife, eight-fan-wing machine in the 14 and 15-inch sizes. As a result of this, two machines were built and tested this year, and the tests, we believe, prove conclusively the practicability of such a machine, and we believe they also prove the desirability of this type.

The Case machine (originally the Belle City) used in these tests was constructed of standard parts. The wheel was drilled for four knives and eight fan wings instead of three and six, and the gear ratio changed to give the correct length of cut. The other Case cutter used a specially designed cast iron spider knife support, which was bolted to the wheel disk. This spider gave great rigidity to the wheel, but apparently needed some slight modifications in order to get proper clearance for the cut material to pass out to the fan wings.

Either of these machines would have a maximum capacity on the ½-inch cut of about 29 tons per hour at 400 r.p.m., nearly 37 tons at 500 r.p.m., and 44 tons per hour at 600 r.p.m. Check this against the usual maximum feeding ability of two men of 20 tons per hour and observe that ample capacity is secured for any and all conditions and at moderate speeds throughout.

A word of caution is in order at this point. The speed of such a cutter absolutely must be kept down when the power is limited, due to its enormous capacity at even moderately high speeds.

There is one condition that must be met in any fair sized cutter to satisfy a psychological reaction of the average user, and that is to maintain a fair speed for the feed table. The three-knife machine at slow speeds does not meet this requirement, but it seems that the four-knife machine does. The table on a four-knife machine running at 450 r.p.m. travels as fast as on a three-knife machine at 600 r.p.m.

The four-knife machine apparently elevated as successfully as any three-knife machine, and its general performance was smooth and very satisfactory in every respect.

Proper Ratio of Feed Table Travel to Feed Roll Speed. The proper speed of the feed table as compared to the peripheral velocity of the feed rolls was the object of a special study on the Blizzard No. 500 13-inch cutter. The results of these tests are shown in Table IV.

The change in the comparative speeds was secured by changing the speed of the feed table and auxiliary feed roll. The length of cut was determined by measuring the feed table travel for a certain number of revolutions of the cutter head, a method which we have always used. Pieces of cut ensilage were also measured and found to coincide quite closely with the calculated length of cut. Therefore, the length of cut varies, being slightly longer where the table and rolls are

*Paper presented at a meeting of the Farm Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December 1, 1925.

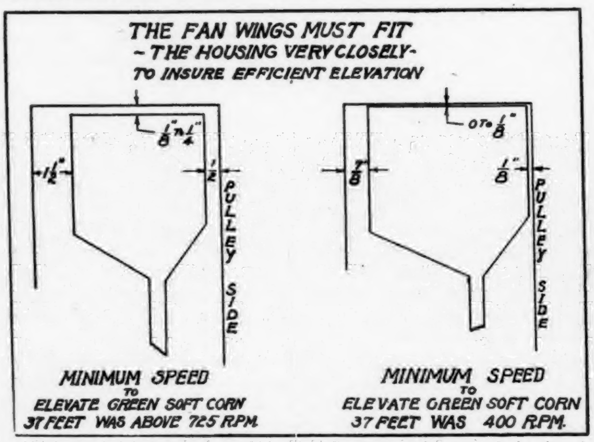
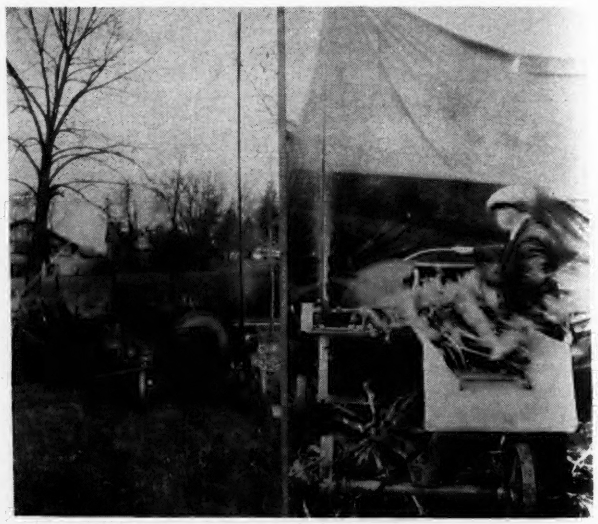


Fig. 1. The results of the experiments with the fan wings designed as shown in this diagram indicate that fan wings must fit the housing very close at the tip and fairly so at the sides to insure efficient elevation



Figs. 2 and 3. These pictures show that the discharge of ensilage from the cutter is in the form of a very thin stream at the periphery of the fan

speeded together. In order to get accurate data, the speed of the entire feeding machanism should have been corrected so as to give the same length of cut in each case. However, the results appear to be sufficiently significant to warrant conclusions that the speed of the table should coincide with the peripheral velocity of the feed rolls.

In one pair of tests the advantage of this ratio is 4.4 per cent and in another 8.06 per cent. However, in the latter pair of tests there is a discrepancy in speed that would account for part of the difference. The gain in both cases is partially due to the longer cut, but probably not entirely.

The principal advantage, however, of having the entire feeding machanism speeded the same seems to be in the general performance of the machine other than the power required.

It was demonstrated conclusively that where the table travels slower than the feed rolls, the table controls the rate of feeding almost entirely, and the feed rolls must therefore be slipping all the time. Incidentally, the feed rolls are quite positive in action on this machine.

With this condition there was more tendency to clog. Apparently the effectiveness of the feed rolls is very materially reduced due to this constant slipping. The action could probably be compared to that of a railroad locomotive; when the wheels begin to slip ever so little they lose their traction almost entirely.

Where the entire feeding machanism was speeded the same, the feed was apparently much more positive.

The strain on the entire feeding mechanism would undoubtedly be greater where the different units were not working together, which would tend to increase breakage throughout the various parts of the driving mechanism.

The question naturally arises as to just what is the proper speed of the table, where the feed rolls are corrugated or saw-toothed as is usually the case. Certainly the peripheral velocity at the tip of the roll is not the proper speed. It would seem that this could only be determined experimentally for each machine, and the following method appears logical:

Equip the feed table with smooth slats, or cover the table all but about one inch along the side with sheet iron, fastened so it will not work into the feed rolls. Then feed a medium-sized bundle through the machine, carefully noting the comparative movement of the bundle and the table. The bundle should be securely tied in two or three places so as to avoid individual stalks feeding faster or slower than the balance of the bundle.

Comparative Performance of Four and Six-Blade Fans on a Cylinder Machine. These tests were conducted on an Eagle No. 75 machine. (See Table V.) The construction of the two fans was supposed to be as near alike as possible, with the exception of the number of fan blades. The results so far as power and elevation were concerned show practically no difference between the four and six-blade fans. However, the six-blade fan made a somewhat smoother running machine, with less vibration in the pipe, although this machine operated very smoothly with either fan.

There was quite noticeably less rumbling and pipe vibration with the six-blade fan, especially when the machine was suddenly slugged.

Some Features Controlling Efficient Elevation. In order to determine quantitatively the effect of fan wing clearance upon elevation and power requirement, the Belle City Manufacturing Company made two complete sets of fan wings at our request. One set had considerable clearance (Fig. 1); the other set fitted as closely as possibly so as not to strike on the tips, and on the side next to the pulley, on the other side, the clearance was about ⅞ inch. The results of this investigation form more of a contrast than a comparison, as the close fitting fan so far outperformed the other, especially with very green soft corn.

The wide-clearance fan failed to elevate even a small quantity of very green corn 37½ feet at 725 r.p.m., and we did not attempt to increase the speed further in order to find out what speed would be required. But with the close fitting fan (Fig. 1) it elevated about one-half capacity at 400 r.p.m. and almost full capacity for the four-knife machine at about 425 r.p.m. The results with more mature corn were not so striking but still showed a wide margin of advantage for the close fitting fan. Here the close fitting fan elevated 53 feet during several tests at about 440 r.p.m. The minimum speed was not determined. The wide clearance fan required 527 r.p.m. to do the same work.

The performance of a close fitting fan is much more clean cut than that of a wide-clearance fan, as can readily be determined by observing the cut corn passing through the elbow at a speed somewhat near the minimum elevating speed.

A study of the results on the Belle City (now the Case) machine (Table I, tests Nos. 11-16) indicate that this difference in clearance does not have a very great effect upon the

Table I. Data on 1925 Silo Filler Tests Conducted by the Agricultural Engineering Department, College of Agriculture, University of Wisconsin

No.	Cutter	Type -flywheel or cylinder	Height of silo - feet	Size of Cutter -inches	Length of cut -inches	Cutter speed -r.p.m.	Fan speed -r.p.m.	Tons per hour	Average horse-power	Horsepower hours per ton
1	Advance-Rumely	Flywheel	30	11	.482	666		12.92	18.91	1.461
2	" "	"	"	"	"	764		12.86	20.60	1.601
3	" "	"	"	"	"	758		14.00	22.47	1.605
4	" "	"	"	"	"	937		14.95	26.66	1.784
5	" "	"	"	"	"	923		16.97	30.70	1.810
6	Blizzard	Flywheel	30	13	.586	525		16.78	15.27	0.910
7	" "	"	"	"	"	654		20.34	24.20	1.190
8	" "	"	"	"	"	779		23.22	33.20	1.430
9	" "	"	53	"	.413	571		11.72	13.25	1.130
10	" "	"	53	"	.413	766		16.51	18.23	1.104
11	Case (1)	Flywheel	37	14	.481	400		19.62	15.15	0.772
12	" (1)	"	37	"	"	506		17.52	16.91	0.965
13	" (1)	"	"	"	"	512		18.88	19.53	1.033
14	" (1)	"	"	"	"	495		21.78	20.30	0.932
15	" (2)	"	53	"	"	443		14.04	12.95	0.922
16	" (2)	"	"	"	"	442		17.75	16.95	0.954
17	Case (3)	Flywheel	37	14	.481	392		18.40	14.50	0.788
18	" (3)	"	"	"	"	400		24.83	20.96	0.844
19	" (3)	"	"	"	"	451		16.28	14.14	0.868
20	" (3)	"	"	"	"	496		23.97	22.82	0.952
21	Case (4)	Cylinder	53	14	.500	1166	1166	14.64	19.29	1.317
22	" (4)	"	"	"	"	1142	1142	15.12	20.70	1.368
23	" (4)	"	"	"	"	1156	1156	11.00	14.80	1.345
24	Eagle	Cylinder	37	75(sq in)	.578	447	776	18.80	17.96	0.955
25	"	"	"	"	"	444	770	20.36	20.05	0.985
26	"	"	"	"	"	456	790	15.54	15.91	1.024
27	"	"	"	"	"	440	762	24.20	23.96	0.990
28	Rowell	Flywheel	53	13	.458	529		16.90	12.89	0.762
29	"	"	"	"	"	535		13.42	12.37	0.922
30	"	"	"	"	"	636		18.60	20.18	1.084
31	"	"	"	"	"	637		16.60	17.17	1.035
32	Smalley	Cylinder	37	70(sq in)	.350	489	547	14.60	13.05	0.894
33	"	"	"	"	"	473	552	14.35	13.51	0.941
34	"	"	"	"	"	564	658	17.18	20.47	1.191
35	"	"	"	"	"	570	664	15.37	17.30	1.125

NOTE: The 53-foot silo for Tests 9 and 10, 15 and 16, 21 to 23, and 28 to 31 would increase the power requirement probably 3 per cent.

(1) A special Case cutter with four knives and eight fan wings instead of three knives and six fan wings. The fan wings used in this test had considerable clearance. Regular knife supports were used.
(2) Same as (1) except the fan wings were close fitting.
(3) Special Case machine with four knives and eight fan wings. Special cast iron spider knife support.
(4) Special Case machine with two knives and four fan wings.

Table II. Specifications of Silage Cutters

Name of Cutter	Type	Size - inches: Rated	Actual throat width	Maximum throat height	Maximum throat opening	Cutter head: No. of knives	Bearings	Fan: Bearings	Diam. -inches	Number blades	Drive	Blow pipe Diameter - inches
Advance-Rumely	Fly.	11	10 1/2	6 1/2	68.2	3	Ball		39	6		6 1/2
Blizzard	Fly	13	12 1/2	6	75.0	3	Babbitt		40	6		6 3/4
Case (Special)	Fly	14	13 3/8	7 5/8	101.7	4	Babbitt		42	8		7
Case (Special)	Fly	14	13 3/8	7 5/8	101.7	4	Babbitt		42	8		7
Case (Special)	Cyl.	14	14	6	84.0	2	Ball			4	Unit	7
Eagle	Cyl.	75	15 1/4	5 1/8	78.0	4	Timken	Timken	36	6	Roller chain	8
Rowell-Trojan	Fly.	13	12 1/8	6 1/4	75.7	3	Hyatt		40	6		7
Rowell-Trojan	Fly.	13	12 1/8	6 1/4	75.7	3	Timken		40	6		7
Smalley	Cyl.	70	14	5	70.0	4	Babbitt	Babbitt	38	6	Roller chain	8

NOTE: See notes following Table I regarding special machines.

Table III. Results of Elevating Tests

No.	Cutter	Type	Size -inches	Length of cut -inches	Height of silo - feet	R.P.M.: Cutter	R.P.M.: Fan	Peripheral velocity of fan -feet per minute
1	Advance-Rumely	Fly.	11	.482	53	708		7350
2	Blizzard	"	13	.413	53	465		4860
3	Case (Sp.-1)	"	14	.481	53	442	(Note 1)	4850
4	Case (Sp. 2)	"	14	.481	53	527		5790
5	Case (Sp. 3)	"	14	.481	53	447		4920
6	Eagle	Cyl.	75(sq in)	.377	53	360	513	4835
7	Rowell(7" pipe)	Fly.	13	.458	53	463		4850
8	Rowell(6½" pipe)	Fly.	13	.458	53	470		4920
9	Smalley	Cyl.	70(sq in)	.350	37	400	467	4630

Special 1. Special four-knife, eight-fan wing machine, close fitting fan wings. Elevated well at 442 r.p.m. Minimum r.p.m. not taken. Regular knife supports.
Special 2. Special machines as Note 1 but with 1/8 to 1/4-inch tip clearance. 1½-inch clearance on knife side and 1/2-inch on pulley side.
Special 3. Special machine with four knives and eight fan wings. Cast iron spider knife support.

power requirement, all other things being the same, there being apparently a slight disadvantage against the close fitting fan in this respect. However, the gain in being able to reduce the speed much more than offsets this disadvantage.

We had hoped to get some information on the subject of fan wing angle but were unable to do so.

Other factors affecting elevation and also power are size of pipe and proper design and clearance of all parts of the knife and supports so as to allow the cut material to move as freely as possible to the fan wings. Clogging between the knife and disk is a very serious trouble, causing bad clogging of the pipe and increasing the power required.

Table VI shows the results of tests on the Rowell machine this year which corroborates the results of the tests of last year on the Case that using too small a pipe interferes slightly with efficient elevation and increases the power required.

Design of Discharge Housing. The character of the discharge from the fan has been studied somewhat, with a view to determining the proper shape of the discharge housing.

In making this study, material was run through the cutter with the entire upper part of the housing removed, and then with the discharge housing and cover in place. A very striking phenomena was observed in the case of one machine, which it has been demonstrated is very efficient in elevation. When all the housing was removed the fan discharged almost at a perfect right angle to the frame, but when the discharge housing was attached, and the machine fed lightly, the material discharged from the top of this at an angle of 20 to 30 degrees from the vertical and inclined away from the outside or toward the center of the machine.

We then removed the housings on two machines and photographed them in operation, first setting up a straight edge tangent to the housing at the point of discharge. Figs. 2 and 3 show that the discharge is in the form of a very thin stream discharged at the very tip of the fan. The photographs would indicate that 90 to 95 per cent of the material was being discharged in a stream not over 2 inches thick.

As discharge housings are constructed at present, the axis of the discharge (Fig. 4) would be very close to the outside side of the pipe. Fig. 4 shows a theoretical condition on a fan blade, and shows the probable cross section shape and area taken on a plane at right angles to the shaft of the wheel. This diagram represents a 14-inch machine with a 6-inch feed roll lift operating at full capacity, a condition seldom encountered, and yet the quantity of material on the fan is rather small. This theoretical analysis is substantiated by Figs. 2 and 3.

From this analysis and from the observations made on the character of the discharge with and without the discharge housing in place, it would seem that a discharge housing as shown in Fig. 5 where the axis of the pipe coincides with the axis of discharge, would give better results.

Study of Air Flow in Ensilage Cutter Pipes. We have also made a limited study of the velocity of the air at different points in the pipe. Readings were taken with a Pitot tube at different distances from the fan. Eleven readings were taken across the pipe parallel to the shaft and eleven at right angles to the shaft at each level as indicated on Fig. 6. All the readings are recorded directly as taken from the water-filled U tube. It is thought that such readings answer our purpose as well as to know the actual velocity, as we are probably interested more in comparative readings at different places than in absolute readings.

These curves (Fig. 6) tend to substantiate the conclusion that the axis of discharge is not in the center of the pipe as the machines are constructed at present. They also tend to indicate that the material in traveling up the pipe caroms from one side to the other, even on those machines that have demonstrated their ability to elevate efficiently.

We believe, however, that the discharge housing design as suggested in Fig. 5 would overcome this and still further improve elevating efficiency, thus permitting of slower operating speeds which would mean more efficient operation in general.

Clearance in Fan Housing at Various Points. It has been demonstrated that a close fitting fan at the point of discharge is essential to efficient elevation. The question naturally arises as to the necessity or desirability for a close fit at other points, particularly at the bottom and on around to the point of discharge, and also at the cut-off.

Tests were made upon the Rowell No. 113 machine first with the housing close enough to the fan, from the bottom to the point of discharge, to carry out a washer 1/16 inch thick. The results are shown in Table VII. The corn was quite mature.

It is assumed that where there is more clearance at the bottom than at the point of discharge, there will be wedging between the ends of the fan wings and the housing. One

Table IV. Results of Tests on the Blizzard No. 500 to Show the Effect of Operating the Feed Table Slower Than the Feed Rolls

	R.P.M. of cutter	Tons per hour	Length of cut -inches	Horsepower -hours per ton	Increase -per cent
Table and feed rolls at same speed;	571	11.72	.413	1.130	
table slower than feed rolls	565	11.64	.366	1.180	4.40
Table and feed rolls at same speed;	766	16.51	.412	1.104	
table slower than feed rolls	850	16.80	.366	1.193	8.06

NOTE: The additional 8.06 per cent in the last pair of tests is at least partially due to the increased speed. In both cases the increase is partially but probably not entirely due to the shorter cut. The feed was more positive with the feed table and rolls traveling together, the machine operated more smoothly and there would probably be less liability of gear and sprocket breakage.

TABLE V. Results of Tests on the Eagle No. 75 to Show the Characteristics of Four and Six-Blade Fans

	R.P.M. of cutter	R.P.M. of fan	Length of cut -inches	Tons per hour	Horsepower-hours per ton
Four-blade fan	497	862	.377	20.82	1.112
" " "	492	852	"	18.14	1.093
" " "	495	858	"	15.61	1.113
Average	495	857		18.19	1.106
Six-blade fan	495	859	.377	20.60	1.123
" " "	481	834	"	18.02	1.075
" " "	502	871	"	14.41	1.189
Average	493	855		17.67	1.129

NOTE: The last test on the 6-blade fan was at a somewhat higher speed and lower capacity than any test on the four-blade fan. If this test is eliminated, the six-blade fan shows a slight superiority of 0.73 per cent. The elevating characteristics of both were about the same. However, the six-blade fan operated smoother and probably would slug less easily in cases of sudden overfeeding. There was but very little pipe vibration in either case but slightly less with the six-blade fan.

Table VI. Results of the Comparison of 6½ and 7-inch Pipes and Timken and Hyatt Bearings on the Rowell Ensilage Cutter

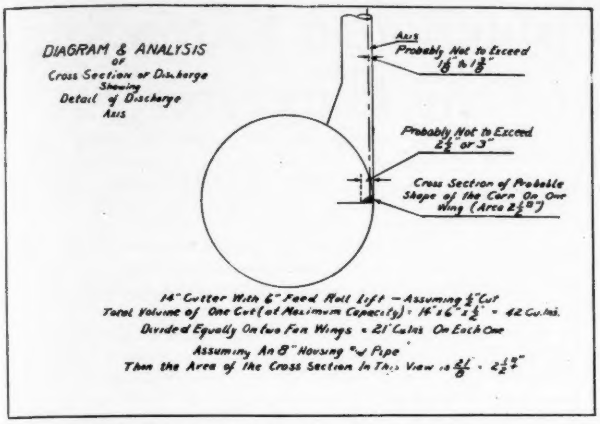
Rowell-Trojan No.113 - 13-inch; silo, 53 feet high

	R.P.M.	Tons per hour	Length of cut - inches	Horsepower - hours per ton	Static air pressure	Per cent increase
Small pipe	636	15.47	.458	1.097		
" "	635	17.34	"	1.120		
" "	631	18.10	"	1.146		
" "	632	20.76	"	1.084		
Avg. " "	634	17.92		1.112	.350	5.0
Large pipe	637	16.60	"	1.035		
" "	635	18.60	"	1.084		
Avg. " "	636	17.60	"	1.059	.724	
Small pipe	532	12.32	"	.912		
" "	534	15.53	"	.879		
Avg. " "	533	13.92		.895	.720	6.3
Large pipe	535	13.42	"	.922		
" "	529	16.90	"	.762		
Avg. " "	532	15.16	"	.842	.500	

Minimum speed to elevate 53 feet with large pipe, 463.5 r.p.m.
" " " " " " " small " , 470.0 r.p.m.

	R.P.M.	Tons per hour		Horsepower - hours per ton
Timken bearings	631	11.97		1.067
	635	13.78		1.100
Avg.	633	12.87		1.083
Hyatt bearings	634	15.47		1.097

NOTE: Reference to last year's tests also the first four tests in this table indicate that this difference is due entirely to the difference in the rate of feeding.



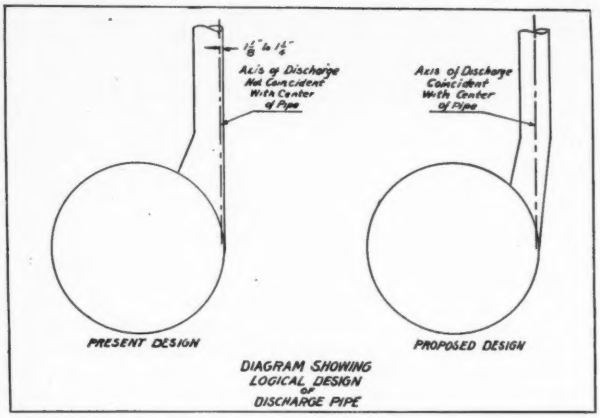


Fig. 4. (Left) This theoretical analysis is substantiated by Figs. 2 and 3. Fig. 5. (Right) The analysis of Fig 4 would suggest a discharge housing as shown on the right

case has been reported where the housing became quite hot, presumably at least partly due to this wedging and consequent excessive rubbing action. The greater draft in the test where the clearance was increased at the bottom is partially but probably not entirely due to the difference in speed.

We have secured no data on the clearance at the point of cut-off, but secured an opinion from an engineer of one of the large blower companies. He stated that as a rule the cut-off should be very close to prevent air leakage at this point and consequent eddying in the discharge stream. In the case of ensilage cutters this would probably tend to interfere with proper elevation.

Standardization of Size Rating. Last year we secured and presented considerable data to show that the capacity of an ensilage cutter was directly proportional to the total throat opening, other things being the same; futher, that the narrowest part of the throat should be measured in making calculations of the area.

Therefore, it would seem that the logical method to follow in rating the size of an ensilage cutter would be on the basis of the total square inches of throat opening. A few companies have already adopted this recommendation and we urge that others do likewise as this seems to be the fairest method of rating cutter sizes.

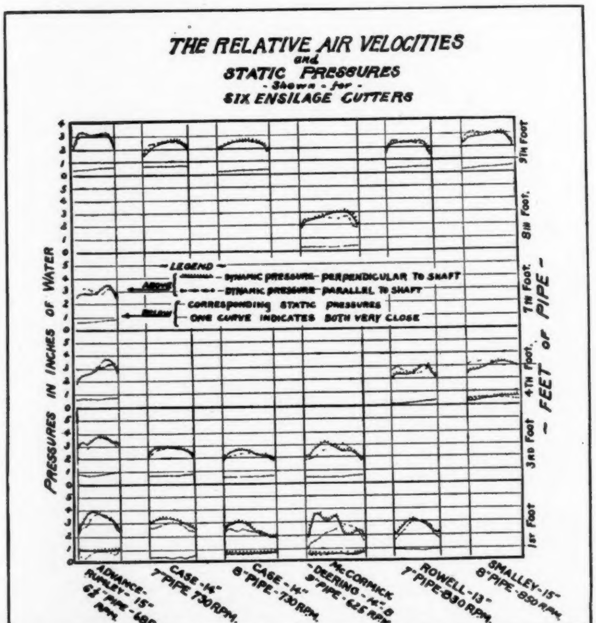


Fig. 6. A study of the air velocities with a Pitot tube indicates that the air current is deflected from one side of the pipe to the other. In all cases for the readings taken perpendicular to the shaft the left-hand side of the diagram represents the outside side of the pipe or the right-hand side, Fig. 5

Standardization of Pipe Connections. In the interest of the user we urge that the pipe connections be standardized. The material and general design may vary to suit the manufacturer, but the number and spacing of the holes can be readily standardized, which will be a great boon to the user in many cases.

Reducing Speed for Efficiency. The efforts which many of the manufacturers as well as the University of Wisconsin have put forth along the line of educating the farmer to operate his cutter at a slower speed are bearing fruit, and I wish to urge continued effort along this line. We should all urge farmers to purchase and use a cheap but efficient revolution counter.

At the present time, we believe it is safe and desirable to recommend the following operating speeds for cutters:

For flywheel cutters—
- 13 inch—540 to 675 r.p.m.
- 14 inch—400 to 625 r.p.m.
- 15 inch—475 to 580 r.p.m.
- 16 inch—440 to 550 r.p.m.

For cylinder cutters—
- 3 knife heads—500 to 600 r.p.m.
- 4 knife heads—400 to 500 r.p.m.

(Continued on page 98)

Table VII. Effect on Power of Increasing the Fan Tip Clearance at the Bottom of the Housing

Rowell-Trojan No. 113 - 13-inch; silo, 32 feet high

No.	R.P.M. of cutter	Tons per hour	Horsepower - average	Horsepower-hours per ton
1	597	12.3	15.77	1.230
2	563	11.2	12.89	1.150
3	633	12.8	16.28	1.272

Nos. 1 and 2. Housing close enough to bottom and delivery side to carry out a washer 1/16 inch thick.

No. 3. Clearance 1/8 inch at discharge side about 5/16 to 3/8 inch at bottom. There is apparently little difference due to the variation in clearance. The differences in the results are due largely to speed variation.

Some Factors to be Considered In Extending The Use of the Combine Harvester*

By M. A. McCall

Agronomist in charge of Cereal Agronomy Investigations, Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture

IN THE readjustment of agriculture through which we are passing, it is universally recognized that the reduction of operating costs is of prime importance. Aside from increased price or increased marketing efficiency, it is obvious that lower costs will at least partially remedy the discrepancy which exists between income and expense in crop production.

Of all the controllable expense incident to producing a cereal crop, labor requires the largest outlay. The present high wage scale and the difficulty of securing satisfactory labor, also, make possible a substantial saving through even a slight reduction in this item.

The crop operations requiring the largest labor outlay are harvesting and threshing. Machines have been substituted for hand labor in harvesting and threshing to a large degree, yet between actual cutting and threshing there still persists a material labor expense. The "combine," harvesting and threshing at one operation, eliminates, in part, this intervening labor, and it is very natural that we turn to this machine as one element in the solution of our problem.

It is important to remember, however, that the combine has been developed and used under rather special conditions, and there are several questions to be answered before we should unqualifiedly recommend its extension to all portions of our cereal producing area. How completely is the combine qualified to meet all the varying conditions under which our cereal crops are grown? If not generally adapted, what are the factors tending to limit its use? Are the limits of use fixed, or can they be extended or entirely removed by improvements in the machine or crop?

Unfortunately, the evidence is not available to answer these questions definitely. Even with a certain amount of preliminary evidence we should hesitate to be too specific in defining limits. The wiser thing is to survey conditions as they exist, to proceed at once in securing the exact information necessary, and to act accordingly. This is the only correct method of attack. Nor should a recognition of obstacles be considered a matter for discouragement, but rather one step in intelligently overcoming them.

While not literally correct, it might be said that the combine is a product of climate. West of the Rocky Mountains, where the combine was developed, rainfall occurs mostly in the fall, winter and spring, and the summer is almost rainless. A crop of grain may remain uncut for a considerable period after being fully ripe, with little likelihood of injury from moisture. The wheat grown in that area in an early day was mostly of the club varieties, which shatter but little. This combination meant an opportunity for a prolonged harvest season. Farming was also on a big scale, so that reduction of equipment was a decided advantage. From this set of circumstances the combine was evolved and first used in California in the late sixty's, although its use did not become general until after 1880. Later the use of this machine spread to all of the dry-farming territory west of the Rocky Mountains. This spread of combine harvesting was made in the face of certain very manifest disadvantages which attend its use even in that particular favorable area.

In the beginning the machines were large, being intended for extensive farming only, and their first cost was high. Because the outfit was expensive and the overhead heavy, and breakdown or delay in operation was costly, it was necessary to hire high-priced skilled operators to insure efficient operation. This has been overcome to a large degree by the introduction of smaller machines and the increase of knowledge in their operation, but the fact still remains that for the individual farmer on a comparatively small farm the investment is a relatively heavy one.

Winds are likewise more or less prevalent in all of this territory and considerable grain is lost by shattering. The club varieties used in early days were little influenced by this factor, but the clubs have been replaced by varieties otherwise more desirable, yet which are not equally resistant to the wind. After prolonged standing, particularly during seasons with more than average wind and on light soils, the grain may lean heavily in the direction of prevailing winds. This adds to the difficulty of harvesting and may result in serious loss if extreme.

Weed seed is allowed to ripen and to shatter before harvest, and even where proper provision is made to collect and bag the weed seed during the harvesting operation, the land usually is more completely seeded with weeds than under other systems of harvest. Because of the prolonged standing, weeds sometimes reach such a size in the grain as to interfere seriosly with the operation of the combine, and may prevent complete gathering of the crop. Sappy weed fragments in the threshed grain also sometimes cause heating and discoloration of the grain, although this may be prevented by proper machine adjustment.

The scattering of the straw behind the combine, while in many instances cited as an advantage, also has its disadvantages as well. If desired for feed or other purposes, the straw must be picked up and stacked. If present in large quantity, it interferes with plowing and other tillage operations. Experience also has shown that large quantities of straw when plowed under are not the benefit we have often supposed.

With all the above admitted deficiencies, however, the use of the combine has persisted and increased, and today the larger part of all dry-farm wheat grown west of the Rocky Mountains is harvested with this machine. Surveys conducted by various agencies, among others the United States Department of Agriculture, show why. For instance, in the Pacific Northwest, the labor requirement for harvesting an acre of wheat with the combine is approximately 2 man-hours and 8 horse-hours. For harvesting and threshing an acre of wheat by other means, the labor requirement approximates 6 man-hours and about the same number of horse-hours as with the combine. Considering all factors, the cost of harvesting an acre of grain with the combine is from one-half to three-fourths that for harvesting and threshing as separate operations. The disadvantages must be very decided to overcome such an advanage.

The foregoing is the story for an area of comparatively rainless summers. East of the Rocky Mountains, where the combine is now spreading because of the demand for cost reduction, conditions are entirely different and the problems to be met are likewise different.

Climatic data from U. S. Weather Bureau records for representative localities bring out the contrast in conditions during the harvest season in the two areas. At Fresno, Calif., the average total rainfall during the two months of June and July is 0.11 inch; at Red Bluff, Calif., 0.50 inch; and at Walla Walla, Wash., during the two months of July and August, 0.82 inch. At Fresno during the entire two months of harvest there is on the average one day of rain, at Red Bluff three, and Walla Walla only six. As would be expected under such conditions, relative humidity also is low. At Fresno the average mean for the two harvest months is 34 per cent, at Red Bluff 38 per cent, and at Walla Walla 40 per cent.

*Paper presented before a meeting of the Farm Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, December 1, 1925.

Compare this with the Great Plains area and the Mississippi and Ohio River Valleys. At Amarillo, Tex., the average total rainfall during June and July is 5.38 inches; at Akron, Colo., during July and August it is 4.60 inches; at Concordia, Kans., during June and July it is 7.93 inches; at Des Moines, Iowa, it is 8.28 inches; at Springfield, Ill., it is 7.15 inches; and at Columbus, Ohio, it is 6.86 inches. During the same periods the average number of days on which rain occurs is 17 at Amarillo, Tex.; 14 at Akron, Colo.; 19 at Concordia, Kans.; 21 at Des Moines, Iowa; 21 at Springfield, Ill.; and 23 at Columbus, Ohio. Average mean relative humidity for corresponding intervals is 61 per cent at Amarillo, Tex.; 50 per cent at Denver, Colo. (substituted for Akron, as data for the latter were not available); 65 per cent a Concordia, Kans.; 67 per cent a Des Moines, Iowa; 67 per cent at Springfield, Ill.; and 66 per cent at Columbus, Ohio. Contrast these latter, all of which from central Kansas eastward are 65 per cent or above, with the 40 per cent and less of the Pacific Coast states.

The combine has been operating with reasonable success in the central and western parts of the Great Plains area for several years, long enough to indicate that it is a permanent fixture. In the western part of this territory, as shown in the foregoing summary, rainfall is lower and relative humidity not so high as farther east. This entire region, also, is characterized by a nocturnal summer rainfall, over 60 per cent of the total occuring at night. This may have a bearing on the opportunity for day-time drying and combine operation. Farther east, in the Mississippi and Ohio River Valleys, the rainfall is more evenly distributed between day and night, with proportionately less opportunity for drying and work during the day. Progressively eastward the total number of rainy days also is somewhat greater. Dews likewise are more frequent and more abundant.

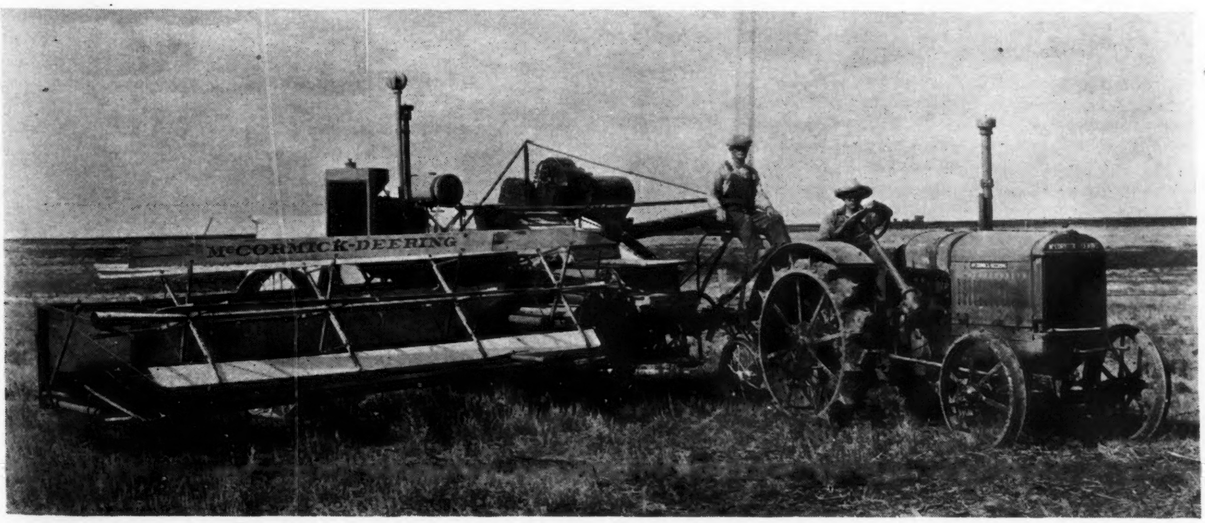
Aside from actual rainfall, any very material increase in relative humidity seriously lessens the efficiency of combine operation. In the Pacific Coast states when harvest is delayed for any reason until late September or early October, there is a material reduction in the number of hours per day during which the combine operates effectively. This reduced efficiency occurs without dew or rain, and is due solely to increased relative humidity brought about by lower temperatures. Nor is this relative humidity extreme, being only about 65 per cent, or equivalent to the normal summer mean east of the Rocky Mountains. The higher temperatures of summer in the latter area, however, undoubtedly give greater drying effect even with a similar relative humidity, so the cases are not exactly parallel. Relative humidity as a factor in efficient operation must not be forgotten, however, its importance being most easily realized from the fact that machine output may be reduced as much at two to five bushels per acre between night and morning operation, simply because of changed relative humidity.

Another factor which has contributed much to the success of combine operation on the Pacific Coast is the fact that only one crop is grown where the combine is used. In the western Great Plains this is also true in large part, but from central Kansas and Nebraska eastward other crops not so well adapted to combine harvesting complicate the problem. While barley is harvested with fair satisfaction, oats usually are not considered suitable for combine harvesting, no known variety possessing the ability to resist shattering or lodging in the necessary degree. Testimony from Kansas emphasizes the combine as less suited for other crops than wheat. Where farm operations are extensive and wheat the principal crop, it might pay to operate the combine for wheat only, cutting the oats with a binder, and later using the combine as a stationary separator. As at present built, the combine is not very satisfactory for this purpose. In considering the machine as a permanent institution, however, such use might well be taken into account in future design. Size of farms and fields must also be taken into account, even the small machines being rather expensive for the small farmer. A ring system might, of course, overcome this disadvantage.

Seasonal variations in rainfall must be considered in their effect on combine use. In harvest seasons of least rainfall on land not too rough the combine undoubtedly can be operated almost anywhere to advantage, but would it be equally satisfactory in the seasons of greater rainfall? It is true that no harvest system is entirely satisfactory in rainy seasons, but we should satisfy ourselves as to the relative efficiency of combine harvesting and other methods.

During the season of 1924 there appeared in some markets a considerable quantity of so-called "sick wheat." This wheat to all outward appearances was normal, but when ground it it gave a product having a peculiar musty odor and flavor. A study of this wheat by the Grain Division of the Bureau of Agricultural Economics, United States Department of Agriculture, showed that the whole difficulty was due to the grain having been placed in storage with a moisture content just under that sufficient to cause heating, but still above the limits of safety. With more general use of the combine harvester, the amount of such grain reaching the market during rainy seasons might be expected to increase. The condition can be corrected by installing special drying apparatus in receiving elevators, but this is a faster increasing expense and which much be taken into account.

When wheat is cut with the binder and carefully shocked and capped, it is possible to protect it gainst a part of the deleterious effects of rain. When it is stacked, still greater



The combined harvester-thresher represents one of the most outstanding present day developments in farm machinery

"In considering this whole matter of extending the use of the combine, the lack of definite information is painfully evident. There is need for a real study of the various factors concerned . . . . . Some of these questions must be answered by the agronomist, others by the engineer, but in any case there should be the closest cooperation between the two."

protection is possible. Ripe standing grain, and particularly ripe grain that has lodged, cannot be protected. It is generally recognized that one heavy shower on exposed wheat will lower the test weight at least one grade, as well as bleaching and otherwise injuring the grain. The decreased test weight is apparently due to a loosening of the bran incident to the grain swelling when wet, the lossened bran not allowing as close packing of the grain in the tester kettle even on subsequent drying. Such wheat also mills less satisfactorily. The bran, being broken and already partially loosened, grinds up to a greater degree in the first break and is not as completely removed from the flour. As a result the ash content of the flour tends to be higher. There is some indication, also, that crude protein content and gluten quality are both lowered, even by light showers. Whether such effects are likely to be more, or less, pronounced when the combine is used should be determined.

Cereal varieties, to be most desirable for harvesting with the combine, should be resistant to shattering and to lodging, but general adaptability to conditions affecting yield in any given locality is much more important than either of these factors. As an example, Gold Coin wheat is grown in certain districts west of the Rocky Mountains in spite of the fact that this variety shatters to a degree ordinarily considered as preventive of combine harvesting. Its yielding ability for those particular localities in comparison with other varieties, is such, however, that it is grown and harvested with the combine in spite of its shattering. As previously mentioned, at one time the club wheats were very largely grown in this same territory, presumably in part because of their non-shattering characteristics and adaptability to combine harvesting. A large part of this acreage is now occupied by other varieties more likely to shatter, but much superior in quality or yielding ability. Baart, the leading spring wheat on the dry lands of the Pacific Northwest, is inclined to lodge following rains and wind. This fact has not caused it to be supplanted by other varieties which lodge less, even though practically all of the crop is harvested with the combine.

In an improvement program, the qualities of non-shattering and strength of straw must not be forgotten. Yield and quality, however, are so outstandingly important that, unless shattering or lodging are extreme, the first-named qualities must be given primary consideration in choosing varieties to be harvested with the combine. Moreover, quality and adaptability in the wheat crop are very closely tied up with certain characteristic types of growth response and these in turn, in some cases, seem to be linked with morphologic characters. Theoretically it should be possible to combine the straw stiffness and non-shattering of the club Hybrid 128 with the quality and other characteristics of Kanred, eliminating the undesirable features of the latter and producing a wheat otherwise as well suited to the Great Plains as is this outstanding variety. Practically, it has not yet been done, and until a successful combination is effected by the plant breeder, it is better to stay with varieties of proven yielding ability and quality, without worrying too much about special considerations.

All this does not mean that we should not attempt to produce varieties better suited to the combine where the machine proves its desirability. Resistance to lodging and non-shattering have always been considered by the agronomist and the plant breeder in improving varieties. These factors have been most emphasized, of course, in the areas where the combine is in general use. In considering possibilities for improvement we all recognize that varieties differ to a marked degree in both characteristics. The Washington Agricultural Experiment Station notes variations in non-shattering ranging from 73 to 96 per cent, and in stiffness of straw ranging from 65 to 99 per cent. The Office of Cereal Investigations of the Bureau of Plant Industry, U. S. Department of Agriculture, in cooperation with many of the western agricultural experiment stations, is attempting to breed varieties possessing both yielding ability and quality, and resistance to lodging and shattering. The results so far secured are most encouraging. As an example, Prelude, a hard red spring variety giving good yields in northeastern Colorado, but which shatters so badly as to be worthy of little consideration, has been used as a parent in some crosses. Selections from these crosses apparently combining all of the good qualities of Prelude and resistant to shattering, have been isolated and are being increased and tested further. Plant breeding is a slow process, however, requiring from 8 to 10 years under most favorable circumstances to develop a variety, test its possibilities, and place it in commercial production, so that at best it will be some time before special varieties can be developed.

In considering this whole matter of extending the use of the combine, the lack of definite information is painfully evident. There is need for a real study of the various factors concerned. The losses incident to actual machine operation have little bearing on the problem, since without doubt the efficiency of properly adjusted combine harvesting as a simple machine operation is superior to that of any other method. We should know, however, just what to expect in the way of loss in grain as an incident of prolonged standing after being fully ripe. We should know how this loss compares with the losses from usual harvesting methods. We should know what effect prolonged standing and exposure have on grain quality, and how the quality of combine-harvested grain compares with that harvested in the usual way. If there are differences in quality, are these differences great enough to offset the advantages of the combine? Is it possible to develop methods to prevent or correct quality losses? Are seasonal fluctuations likely to prevent using the combine each year? If so, what provision can be made for handling the crop in the wet season? Can we afford to introduce the combine into areas of multiple cropping, when the machine may not be suited for all the crops grown? How are other crops to be cared for without unnecessary multiplication of equipment? How about the combine in areas of relatively small fields? Can objections be overcome by changes in machine design and size, retaining only the general principle of a combined operation? And above all we should make a complete and careful survey of climatic factors so that we may know the exact probability of rainfall, its frequency and quantity, and all attendent factors as they affect the efficient operation of these machines.

Some of these questions must be answered by the agronomist, others by the engineer, but in any case there should be the closest cooperation between the two. We are all interested in truth and progress and in the protection of the farmer and the manufacturer from unnecessary loss. In the past the development of farm implements has been a matter of cut-and-try experiment, and has included too large a proportion of failure in comparison with success. That day is past, and the very existence of the American Society of Agricultural Engineers is evidence that from now on development is to be on a more sound scientific basis. In attacking this problem, therefore, we must proceed, not with less enthusiasm, but with more careful and thoughtful consideration of all phases of the problem. The combine will then find its true place and greatest usefulness.

Are Current Ideas Basing Duty of Water Experiments Sound?

By F. J. Veihmeyer

Mem. A.S.A.E. Associate Irrigation Engineer, College of Agriculture, University of California

IN THE arid and semi-arid sections of the West agricultural engineers have devoted much effort to so-called duty of water studies. The need for basic information concerning the water requirements of agricultural crops is urgent. Recent studies by the Division of Irrigation Investigations and Practice of the University of California college of agriculture have yielded results which raise serious objections to much of the previous work on the relation of soil moisture to plant growth.

The literature reporting studies with plants grown in containers under supposedly constant soil moisture conditions is voluminous. However, after a rather exhaustive search, I have been unable to find any work of this nature free from the doubt that the moisture in the soil was not maintained constant as the investigator supposed. Dependence upon capillary movement of soil moisture to cause a uniform distribution throughout the mass of soil of water applied at any point has been the cause of error. Numerous trials have been made by the above-named division to maintain a relative low moisture content in soils in containers and also in field plots, but all attempts to apply water either from above or below, or by means of specially arranged perforated pipe-irrigators with the object of establishing a moisture content less than the full field or capillary capacity throughout the soil mass, have met with failure. It is my opinion that relative low moisture contents cannot be maintained in large masses of soil either in containers or in field plots. Then, much of the experimentation upon which current opinion concerning the utilization of water by plants is based, must be of doubtful value.

A prune tree in a tank automatically balanced. The tank containing the soil and tree is partly floated in water contained in the outer tank and balanced by the weight on end of the channel-iron frame. The frame is supported on a knife edge. When the tree transpires the tank rises and is again balanced and the movement is recorded on the recording apparatus connected to the end of the frame. Losses of moisture as small as four ounces can be recorded. The tank weighs about 1100 pounds and during the tests the tank is covered with a metal cover so that losses of moisture are confined almost entirely to transpiration

Studies at the California Agricultural Experiment Station with young prune trees grown in tanks on clay loam soils have shown that the use of water by these trees apparently is not influenced by the amount of water available for growth in the soil. However, when the moisture content of the soil was reduced to a percentage which agreed closely with the calculated wilting coefficient the trees wilted and did not recover until water was applied to the soil.

High coefficients of correlation were found between the use of water and leaf-area of the trees and use of water and length-growth. The same amount of water was transpired per unit of leaf-area and the same length-growth was made per pound of water transpired in spite of the fact that the trees under observation were grown on soil in which the moisture content varied between wide ranges. Some of the trees were on water-logged soil which also received frequent surface applications; others were on soil which were only irrigated when the moisture content had been reduced a slight amount; some were on soils which were allowed to dry out almost to the wilting coefficient, and there were combinations of these soil moisture variations.

A prune tree, automatically balanced so that a very small decrease in weight of the tank due to extraction of moisture from the soil and loss by transpiration could be measured and recorded, afforded an opportunity to observe closely the use of water by the tree at different moisture contents and under different atmospheric evaporating power. (See accompanying illustration.) The records obtained from this tree clearly show that water was used at the same rate per unit leaf-area when the atmospheric evaporating power was the same when the soil moisture content was reduced almost to the wilting coefficient as it was when the soil was filled to its maximum field or capillary capacity.

The results obtained in these studies justify the statement that the use of water by these young prune trees grown on clay loam soil in containers was not influenced by differences in amounts of water available for growth and that optimum moisture conditions for growth cover a range of soil moisture from the maximum field or capillary capacity to about the wilting coefficient. It must be remembered, of course, this applies only to young prune trees on the loam soils and under the conditions of the experiments. However, it does appear that current views concerning the water relation of other plants might also be questioned. Furthermore, I believe there is no reason, either from consideration of the magnitude and variation of physical forces with which the water is held by the soil or from the physiological requirements of ordinary plants, why optimum moisture conditions for good growth should not extend from the maximum field or capillary capacity to about the wilting coefficient.

This brief discussion is submitted in advance of the publication of a paper giving the full details and results of the studies in the belief that agricultural engineers who are concerned with duty of water investigations may be interested in the facts which may change the conception of the effect of application of different amounts of water on yields as is now generally held by workers in this field.

(EDITOR'S NOTE: The work of Mr. Veihmeyer along the lines of the water requirements of agricultural crops is of outstanding significance and inportance. It upsets much of the generally accepted knowledge on the relation of soil moisture to plant growth. The results of Mr. Veihmeyer's studies will be invaluable to those engaged in duty of water investigations. This is just another example of the many discoveries that await the research worker in the agricultural field. It is indeed a challenge to the agricultural engineer.)

Research in Agricultural Engineering

A department conducted by the Research Committee of the American Society of Agricultural Engineers

A Study of the Dynamics of the Disk Harrow

By E. G. McKibben

Assoc. Mem. A.S.A.E. Junior Agricultural Engineer, University of California

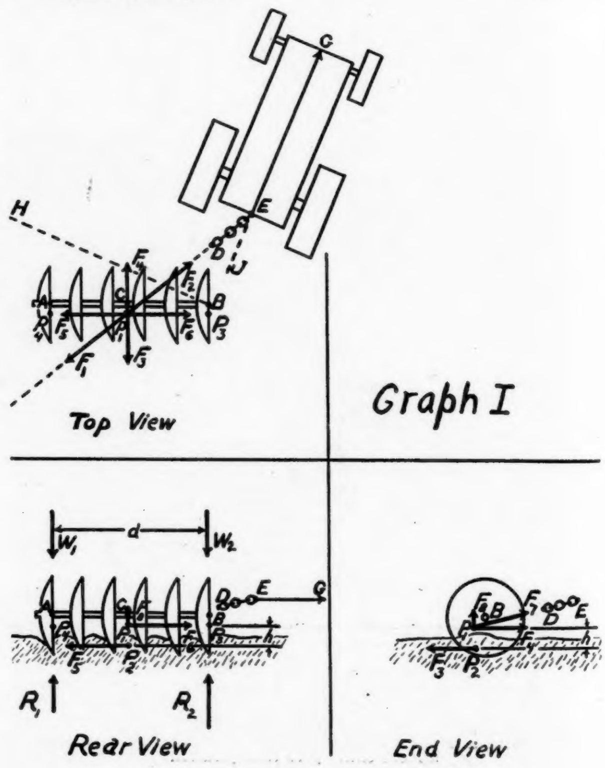
DURING the past year there has been developed and placed on the market a disk harrow (Fig. 2) differing fundamentally in its design from the conventional type. Unlike the conventional type, in order to be operated without side draft, the point of hitch must be offset to one side of the center of the harrow. Thus if the hitch is made to the center of the tractor and to the proper point on the harrow, a tillage implement is obtained, which operates without side draft but which tills a strip of land whose center falls considerably to one side of the center of the tractor.

The unusual performance of this harrow started the work upon which this paper is based. A complete analysis, based on the proven laws of mathematics and mechanics, was made of the fundamental dynamic principles involved in the operation of a disk harrow. This analysis was checked by field work, qualitative rather than quantitative. By the use of qualitative tests, that is, tests in which the change, in a given variable, was great enough to minimize the effect of the inevitable slight changes in the controlled variables, and great enough to leave no doubt as to its relation to the tendency result obtained, it was possible to obtain definite information concerning the fundamentals involved, with a comparatively few tests. Quantitative tests, that is, tests which deal with the exact numerical relation between the magnitude of the change of a given variable and the results obtained, involve a very great expenditure of time and money if they are carried to the point where they are of any value. Also, they generally have to be indefinitely repeated for each new set of conditions. Therefore, they have been left to the manufacturer whose problem it is to determine the details of design, and the farmer who has a specific set of field conditions to meet.

The first step consisted of the study of a single gang. The gang used (Fig. 1) consisted of eight blades spaced nine inches apart. The blades were 20 inches in diameter and had a concave depth of 2 inches. This gang was connected to the drawbar of a tractor with a chain as shown in Fig. 1. All the external forces acting on such a gang may be combined into three forces: The drawbar pull, the action of gravity due to the weight of the gang, and the resultant of combining the soil reactions against each blade. The direction of the drawbar pull is indicated by the chain. The line of action of gravity is, of course, vertical. By applying equilibrium force and moment equations the relative magnitude and direction of the third force, the soil reaction, required for uniform motion may be determined. This is shown graphically in Graph I.

Notations for Graph I

A, convex end of gang
B, concave end of gang
C, center of gang
D, point of attachment of chain to frame of gang
E, point of attachment of chain to frame of tractor
DE, direction of action of drawbar pull
F_1, resultant of horizontal components of the soil reactions against blades of gang
F_2, horizontal component of drawbar pull
F_3, component of F_1, perpendicular to AB
F_4, component of F_2, perpendicular to AB
F_5, component of F_1, parallel to AB
F_6, component of F_2, parallel to AB
F_7, component of drawbar pull parallel to a vertical plane perpendicular to AB
F_8, vertical component of drawbar pull
JG, direction of uniform motion
HB, line perpendicular to direction of motion
h, distance between P_1 and P_2
d, distance between A and B
P_1, point of intersection of line DE with a vertical plane perpendicular to AB through C. This point is determined by the direction of chain DE.
P_2, point of intersection of line of action of F_1, with a vertical plane perpendicular to AB, through C. Its horizontal position is determined by the horizontal direction of DE and is in the same vertical line as P_1. Its vertical position is not so easily determined but it is somewhere between the bottom edge of the blades and surface of the soil.
P_3, point of intersection of the line of action of F_6 with a vertical plane through B perpendicular to AB
P_4, point of intersection of the line of action of F_6 with a vertical plane through A perpendicular to AB
R_1 and R_2, vertical forces acting through A and B, respectively, which will give the same result as the resultant of combining the vertical components of the soil reactions against the blades



W_1, weight at A when weight of entire gang is supported at A and B

W_2, weight at B when weight of entire gang is supported at A and B

Conventions and Conditions

1. All forces acting up or to the right are considered as positive.
2. All forces acting down or to the left are considered as negative.
3. All moments tending to produce a counter clockwise rotation are considered as positive.
4. All moments tending to produce a clockwise rotation are considered as negative.
5. The condition of uniform rectilinear motion is the only one considered.
6. A uniform soil condition under all blades of the gang is assumed.

Fundamental Force Equations

$$F_1+F_2=0 \tag{1}$$

(The algebraic sum of all horizontal forces must equal zero.)

$$F_3+F_4=0 \tag{2}$$

(The algebraic sum of the components perpendicular to AB of all horizontal forces must equal zero.)

$$F_5+F_6=0 \tag{3}$$

(The algebraic sum of the components parallel to AB of all horizontal forces must equal zero.)

$$R_1+R_2+W_1+W_2+F_8=0 \tag{4}$$

(The algebraic sum of all vertical forces must equal zero.)

Variables. Taking one at a time, large changes were made in the following variables: Location of point D, soil condition, speed, and amount and distribution of weight supported. In each case enough runs were made to determine the tendency result of the change. In all cases these tendency results, obtained by the field study can be explained by the application of the principles of mathematics and mechanics.

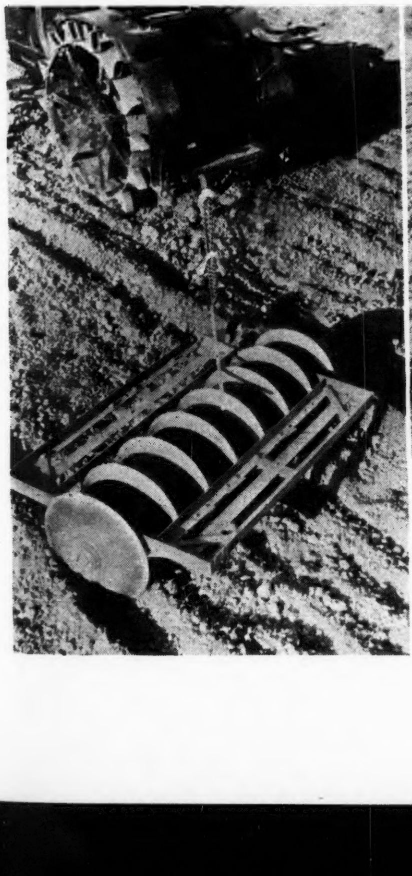
Point of Hitch. (See top view of Graph I.) Increasing the angle DCB, within the ordinary operating ranges, by changing the position of D, with respect to the gang, decreases the angles HBC. As angle DCB approaches 90 degrees the angle HBC approaches zero; and as DCB approaches zero, HBC approaches 90 degrees. As the angle DCB approaches 90 degrees, the angle DEJ approaches zero. As the angle DCB is decreased within the usual operating range, the angle DEJ increases. However, if the angle DCB is decreased beyond a certain point (determined by design of blades, weight supported, soil condition, and speed), the angle DEJ decreases again with the result that, as DCB approaches zero, DEJ also approaches zero. If the horizontal position of D is kept fixed, with respect to the gang and the gang is so weighted that the blades will have equal penetration, the horizontal position of the point P_1 will remain practically fixed with respect to the gang. If the horizontal position of D and P_1 remain fixed with respect to the gang, the ratio of F_3 to F_5 must remain constant irrespective of the magnitude of F_1 or the angles DEJ and HBC.

Decreasing the angle DCB also tends to increase the penetration which produces the same tendency results as those noted below under increased penetration due to changed soil conditions.

Soil Condition. In general any change in soil conditions which results in greater penetration of the disk blades produces two opposing tendencies. First, due to the shape of the blades, as the penetration increases with a given value for angle HBC the ratio of F_3 to F_5 increases. This means that either angle DP_1P_3 must be increased by changing the position of D with respect to the gang, or the angle HBC must be increased to the point where the ratio F_3 to F_5 again has its inherent value for the given position of D. In either case angle DEJ will be decreased. If the distribution of the weight supported by the gang is so changed as to maintain equal penetration of the blades, the above would be the only result.

Considering the changed soil condition as the only change, there will be a second tendency result. Irrespective of the effect of the deeper penetration upon the ratio of F_3 to F_5 the magnitude of F_5 and consequently F_6 will be increased. (See rear view Graph I.) As will be shown below, this causes the increase of penetration to be greater at B than at A. Therefore, the point P_1 tends to move to the rear from C and the line of action of forces F_1 and F_2 tends to pass closer to B. This results in increasing the angle DP_1P_3 and decreasing the angle HBC. However, under the usual field conditions the first tendency is the most important and the net result of deeper penetration due to a change in soil condition is an increase in the angle HBC.

Speed. Within the range of usual field speeds of from one to three miles per hour the effect of speed changes on the position of the gang is not marked, although decreased speed tends to increase the penetration of the blades with the same tendency results as those produced by increased penetration due to changed soil conditions.



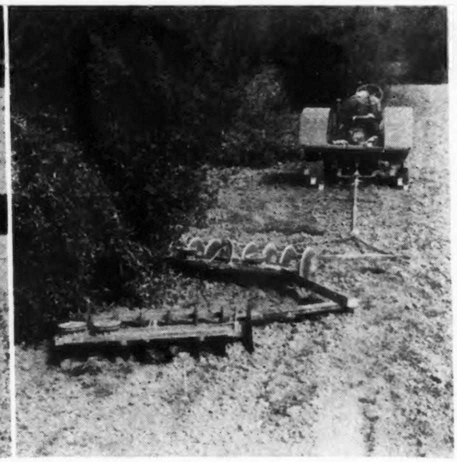


Fig. 1. (Left) The rear gang of a 6½-foot Towner cover crop disk harrow. This picture illustrates the method used in studying the force reactions on individual gangs

Fig. 2. (Middle) Note the offset without side draft. The disk harrow shown is manufactured by Towner's, Santa Ana, Calif., and marketed by Dixon, Griswold & Company, Los Angeles, Calif.

Fig. 3. (Right) Note the angle irons connecting the gangs, the offset without side draft, and the relative position of the hinge point with respect to the line of draft

Weight. Increasing the weight supported by each blade increases the penetration with the same results upon the position of the gang as those caused by increased penetration due to changed soil conditions.

Increasing the weight supported by one end of the gang results in increased penetration of the blades at that end of the gang. This causes the position of point P_1 to change, with respect to the gang, and the position of the gang to change, with respect to the tractor, so that the line DP_1 will pass nearer the end of increased weight. This either increases or decreases the angle HBC, depending upon whether the weight has been added at A or B.

Gang Held Rigidly in Frame. If the gang is held rigidly in a frame so that the angle HBC cannot change, deeper penetration, due to changed soil conditions, lessened speed, or increased weight will result in a permanent increase of the ratio F_3 to F_8 and a consequent increase of the angle DP_1P_2.

Equal Penetration of Disk Blades. Experienced operators know that, if both ends of a gang are equally weighted, deeper penetration will be obtained at B than at A. From the following moment equations it is evident that if the penetration of the disk blades is to be equal, the relationship between W_1 and W_2 must be

$$W_1 = W_2 + \frac{2F_5h}{d}$$

Consider moments about a horizontal axis through point P_2 and perpendicular to the line of action of F_6. The line of action of forces W_2, R_2, and F_6 all pass through this axis. Therefore, their moment about this axis is equal to zero. This leaves the following moment equation:

$$-R_1d + W_1d - \frac{F_8d}{2} - F_5h = 0 \tag{5}$$

Solving (5) for R_1,

$$R_1 = W_1 - \frac{F_8}{2} - \frac{F_5h}{d} \tag{6}$$

Consider moments about a horizontal axis through point P_1 perpendicular to the line of action of F_6. The lines of action of forces W_1, R_1, and F_6 pass through this axis. Therefore, their moment about this axis is equal to zero. This leaves the following moment equation:

$$R_2d - W_2d + \frac{F_8d}{2} - F_5h = 0 \tag{7}$$

Solving (7) for R_2,

$$R_2 = W_2 - \frac{F_8}{2} + \frac{F_5h}{d} \tag{8}$$

If equal penetration is to be obtained the vertical reactions R_1 and R_2 must be equal, that is,

$$R_1 = R_2$$

and from equations (6) and (8)

$$W_1 - \frac{F_8}{2} - \frac{F_5h}{d} = W_2 - \frac{F_8}{2} + \frac{F_5h}{d} \tag{9}$$

Simplifying (9),

$$W_1 = W_2 + \frac{2F_5h}{d} \tag{10}$$

Couples. In addition to the above solution, it is of interest to note that forces F_5 and F_6 are numerically equal, opposite in direction, parallel and non-concurrent. Therefore, they form a couple with a moment arm (h) and a negative moment ($-F_5h$), tending to produce clockwise rotation. This couple can be balanced only by a couple whose moment is equal to (F_5h), tending to produce counterclockwise rotation. An analysis of equations (6) and (8) indicates the source of the forces which constitute this balancing couple.

Equation (6) shows that the reaction R_1 at A is numerically $\frac{F_5h}{d}$ less than the numerical value of the algebraic sum of W_1 and $\frac{F_8}{2}$. This means that a part of W_1, whose algebraic value is $\left\{-\frac{F_5h}{d}\right\}$, is being opposed by some other force than either the soil reaction or the vertical component of the drawbar pull.

Equation (8) shows that the reaction R_2 at B is numerically $\frac{F_5h}{d}$ greater than the numerical value of the algebraic sum of W_2 and $\frac{F_8}{2}$. This means that a part of R_2, whose algebraic value is $\left\{\frac{F_5h}{d}\right\}$, is being opposed by some other force than either the weight of the disk or the vertical component of the drawbar pull.

Thus there is a vertical force $\left\{-\frac{F_5h}{d}\right\}$ acting through point A and a vertical force $\left\{\frac{F_5h}{d}\right\}$ acting through point B, neither of which is balanced by a concurrent force. These two forces are numerically equal, opposite in direction, parallel, and non-concurrent. Therefore, they form a couple with a moment arm (d) and a positive moment $\left\{\frac{F_5hd}{d}\right\}$ or (F_5h), tending to produce counterclockwise rotation. This couple balances the couple formed by forces F_5 and F_6.

Vertical Position of Points P_1 and P_2. If point P_2 coincides with P_1, h will equal zero and $\frac{2F_5h}{d}$ will equal zero, and equal penetration will be obtained when $W_1 = W_2$.

If point P_2 is above P_1, then the direction of the moment F_5h will be reversed and extra weight will have to be added to W_2 at B in order to obtain even penetration.

However, under the usual field conditions point P_2 will fall below point P_1.

Provisions for Weighting Disk Harrows. Therefore, if, under the usual field conditions, equal penetration of the blades is to be obtained, either extra weight must be added at A or the gang must be held rigidly in a frame which is not free to rotate in a vertical plane parallel to AB. Therefore, if provision is made for the addition of weight, better operation will be obtained and certain stresses relieved if the design is such that more weight is added at A than at B.

Horizontal Position of Points P_1 and P_2. With the gang so weighted that equal penetration of the blades is obtained, points P_1 and P_2 fall somewhere back of point C. This is explained by the fact that the back half of that part of the disk blade which penetrates the soil has a greater angle with the direction of motion than the front half.

Some Fundamental Principles. When considering the possibilities of combining gangs, the following fundamental principles must be kept in mind; these principles apply equally to any tillage implement:

Horizontal Forces

1. The algebraic sum of all horizontal forces acting upon the implement must be zero.
2. If one of these forces is a drawbar pull, its horizontal component must be a force equal in magnitude, parallel, opposite in direction, and horizontally concurrent to the resultant of all resisting horizontal forces.

Horizontal Forces Parallel to Direction of Motion

3. The algebraic sum of the components, parallel to the direction of motion, of all horizontal forces acting upon the implement must equal zero.
4. The component of the drawbar pull parallel to the direction of motion (the force determining the power developed) is numerically equal and opposite in direction to the resultant of the components, parallel to the direction of motion, of all horizontal resisting forces.

Horizontal Forces Perpendicular to the Direction of Motion

5. The algebraic sum of the components, perpendicular to

the line of motion, of all horizontal forces acting upon the implement must equal zero.

6. The horizontal component of the drawbar pull perpendicular to the direction of motion (side draft) is numerically equal and opposite in direction to the resultant of the components, perpendicular to the direction of motion, of all horizontal resisting forces.

No Side Draft

7. If the horizontal component of the drawbar pull is parallel to the direction of motion (condition for no side draft), it will have no horizontal component perpendicular to the direction of motion, and the algebraic sum of the components, perpendicular to the direction of motion, of all horizontal resisting forces, will equal zero.

Moments of Horizontal Forces

8. The algebraic sum of the moments of all horizontal forces about any point must be zero.

9. Therefore, if the horizontal resisting forces are combined into two resultant forces the line of action of the drawbar pull must be horizontally concurrent with the intersection of the line of action of these two forces.

Notations for Graph II

A_1, A_2, A_3, A_4, points of hitch—
- A_1, located on the line through P_1, parallel to the direction of motion.
- A_2, located to the left of A_1P_1
- A_3, located to the right of A_1P_1
- A_4, located on the line through P_3 parallel to the direction of motion.

BC, line of action of horizontal component of soil reaction against gangs L_1, L_2, L_3, L_4

B_1C_1, line of action of horizontal component of soil reaction against gang M

DE, line of action of horizontal component of soil reaction against gangs, R_1, R_2, R_3, R_4

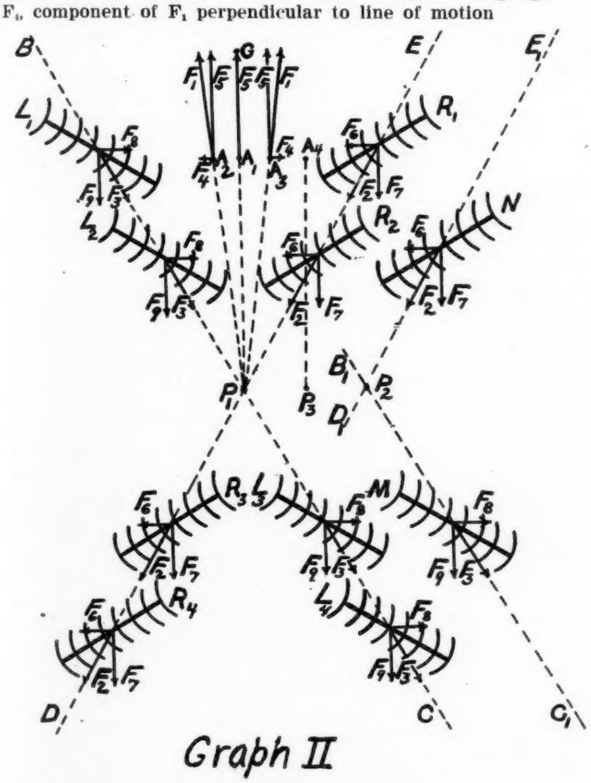
D_1E_1, line of action of horizontal component of soil reaction against gang N

F_1, horizontal component of drawbar pull

F_2, horizontal component of soil reaction against R gangs

F_3, horizontal component of soil reaction against L gangs

F_4, component of F_1 perpendicular to line of motion



Graph II

F_5, component of F_1 parallel to line of motion

F_6, component of F_2 perpendicular to line of motion

F_7, component of F_2 parallel to line of motion

F_8, component of F_3 perpendicular to line of motion

F_9, component of F_3 parallel to line of motion

A_1G, direction of motion

L_1, L_2, L_3, L_4, gangs cutting to the left, similar in every respect except their location along line BC

M, gang cutting to the left similar in every respect to L_3, except its lateral position

N, gang cutting to the right similar in every respect to R_3, except its lateral position

P_1, intersection of lines BC and DE

P_2, intersection of lines B_1C_1 and D_1E_1

P_3, point midway between P_1 and P_2

R_1, R_2, R_3, R_4, gangs cutting to the right similar in every respect except their location along the line DE, and similar to gangs L_1, L_2, L_3, L_4, except in respect to direction of cutting and location along line DE instead of BC

Combining Gangs. (See Graph II.) The possibilities of combining gangs to form harrows, and the behavior of the harrows thus formed may be determined from the above analysis of the dynamics of a single gang, and the above stated fundamental principles. A harrow which may be pulled from any point along line A_1P_1 without side draft may be formed by combining any even number of the L and R gangs, shown in Graph II, providing an equal number of each is taken.

In the conventional arrangements half of the gangs are on each side of line A_1P_1. The conventional type of single-disk harrow is formed by gangs L_2 and R_2; the conventional disk type ridger is formed by gangs L_3 and R_3; and the conventional double-disk harrow is formed by gangs L_2, R_2, L_3 and R_3.

It is possible to form harrows having all the gangs on the same side of line A_1P_1. A disk harrow formed by gangs L_2 and R_3 is shown in Fig. 2. Using the gangs of the harrow shown in Fig. 2, experimental harrows were assembled using gangs L_1 and R_4; L_1 and R_3; and L_2 and R_4. The harrow using gangs L_1 and R_4 is shown in Fig. 3.

Hitch Point and Side Draft. If the hitch point is located on the line A_1P_1, the drawbar pull will have no horizontal component perpendicular to the direction of motion. Therefore, the algebraic sum of F_6 and F_8 must be zero, and F_6 and F_8 must be numerically equal and opposite in direction. Assuming the same soil under each gang, this means that the L and R gangs must have the same angle, otherwise F_6 and F_8 would not be numerically equal. Of course, in any type of double-disk harrow the soil condition under the front and rear gangs is different. However, the difference in angle required to make F_6 numerically equal to F_8 is very small.

If the hitch point is not located on line A_1P_1, but is to the left or right, as A_2 or A_3, the force F_4 will appear. This means that forces F_6 and F_8 will no longer be equal but must have a numerical difference of F_4. The algebraic relation of F_6, F_8, and F_4 will be

$$F_6 + F_8 + F_4 = 0$$

If the hitch point is at A_2, F_4 will be negative, and F_6 will be numerically smaller than F_8, meaning that R gangs will take a smaller angle and the L gangs a larger angle than if the hitch is on line A_1P_1. If the hitch point is at A_3 the opposite effects will be produced.

Characteristics of Conventional Arrangement of Gangs. The conventional arrangement has certain inherent characteristics. As long as the soil conditions are uniform and the angles and weights of opposing gangs are the same, the hitch point for no side draft remains the same, irrespective of changes in angles, soil condition, weight or speed. The hitch for no side draft places the harrow directly behind the tractor. This is an advantage in open field work but a disadvantage in some orchards where the branches are long and close to the ground. If the gangs are held rigidly in the frame, their position laterally opposite each other causes the tendency of each to rotate in a vertical plane parallel to the gang bolt to balance the same tendency of the other. Thus, even penetration of the blades may be obtained without the addition of extra weight at the convex ends of the gangs. One of the undesirable characteristics of this arrangement is that there is an uncut strip of soil left at the center of the harrow.

Characteristics of New Arrangement of Gangs. The most important characteristic of the arrangement, which has all the gangs on one side of A_1P_1, is the fact that when the hitch is adjusted for no side draft the center of the harrow is considerably offset from the center of the tractor. If two of gangs L_1, L_2, R_3, and R_4 are used, the offset will be to the left. If two of the gangs R_1, R_2, L_3 and L_4 are used, the offset will be to the right. This offset is of great value in cultivating close to the trees in orchards where the branches are long and close to the ground. This is particularly true when using a tractor in a citrus grove. It also makes possible the disking of irrigation and drainage ditches, and of levee banks, with very little side draft and with the tractor operating on the top of the bank. The only limits to the amount of this offset are the distance to which it is practicable to separate the centers of the gangs, and the difficulty of designing and supporting a hitch extending from the harrow frame to line A_1P_1. By the proper design it would be possible to use two absolutely similar gangs which could be used either as L_2 and R_3, or R_2 and L_3, thus permitting either the left or right offset.

However, the fact that such a harrow cannot be placed directly behind the tractor without side draft has certain disadvantages. First, the tractor is farther from the nearest edge of the former cut. This makes it more difficult to steer at the proper distance unless a marker is used. Second, in finishing between tree rows there will be one tractor wheel track left on the disked soil between each row of trees.

For a given angle, weighting, and distance between gangs of a given harrow, operating on given soil conditions, and at a given speed, there is a definite line A_1P_1 upon which the hitch point must be located to prevent side draft. Within practical operating limits, decreasing the angle by rotating each gang horizontally about its center, increasing the weight, decreasing the distance between the centers of the gangs, changing the soil conditions so as to cause deeper penetration, or decreasing the speed, causes the line A_1P_1 to move toward the center of the harrow. Opposite changes, of course, produce the opposite result. This change of hitch point required for no side draft due to changing conditions is one of the inherent disadvantages of this arrangement. However, the effect produced by the changing conditions found in the average field is not great enough to make this disadvantage of great importance.

By using a combination of gangs corresponding to L_1 and R_3, a harrow is formed which will throw soil toward the trees, and by adjusting the gangs so as to correspond to L_2 and R_4, soil will be thrown away from the trees.

By connecting the gangs with a properly located hinge joint, as shown in Figs. 2 and 3, the rear gang is free to swing. Both gangs will take approximately the same angle in accordance with the principles given under the heading, "Hitch Point and Side Draft," above. This construction has at least two advantages. The rear gang which extends farthest to the left can be equipped with the proper bumper, and in case the operator drives too close to the trees, which sometimes happens, the rear gang will swing back thus allowing the harrow to pass with very little injury to the tree. In turning short to the right the rear gang swings back allowing both gangs to follow around the circle, and in turning short to the left the gangs come together so that they have either no angle or are angled slightly in the opposite direction. This reduces the power required for turning which is very important in orchard and vineyard work.

This arrangement also has the advantage that it does away with the uncut strip at the center of the harrow, and the disadvantage that it is almost impossible to obtain equal penetration of the blades without the addition of extra weight at the convex ends of the gangs, especially of the rear gang.

Interchanging the Gangs of a Conventional Double Disk. The left front and rear gangs of a conventional type double-disk harrow were interchanged. This gave a gang arrangement similar to R_2, L_3, M, and N of Graph II. This harrow is shown in Figs. 4 and 5. Such a harrow may be pulled from any point along the line A_4P_2 without side draft. This is shown in Fig. 4. As is also shown in Fig. 4, it was necessary to chain the rear gang to the hitch to prevent it from moving to the right, and it was necessary also to weight the convex ends of the gangs in order to secure equal penetration of the blades. It is easily possible to design a double-disk harrow in which this change could be rather easily made, thus having either an offset harrow for cultivation near trees and in ditches, or a conventional double-disk harrow for finishing between the rows and doing open field work.

CONCLUSIONS

1. By the proper arrangement of gangs it is possible to obtain a disk harrow, which tills a strip of land, the center of which is offset from the center of the tractor, and which at the same time operates without side draft upon either the harrow or the tractor.

2. For a given disk harrow with a given arrangement, position, angle, and weighting of gangs, operating at a given speed, on given soil conditions, there is only one position behind the tractor where it can be operated without side draft.

3. It is possible to design a disk harrow in which the gang arrangement could be easily changed so that it might be operated, without side draft, either directly behind the tractor or with either a large right or left-hand offset.

(EDITOR'S NOTE: The work on which this article is based represents an important contribution to the development of offset cultivating machinery which is needed especially to meet the difficult and sometimes costly requirements of orchard cultivation. More important still from the standpoint of the Research Committee of the American Society of Agricultural Engineers, this work illustrates most admirably how the proper manipulation of fundamental engineering knowledge and of analytical methods will solve such problems with accuracy and dispatch, whereas the cut-and-try method so commonly used not only frequently fails but often wastes time and money. While this article is a contribution from the California Agricultural Experiment Station, it has been prepared in its present form at the request of the Research Committee to constitute a feature of its program of instruction in the use of proper and effective research methods.)

Fig. 4. (Left) The Oliver orchard type disk harrow. Note offset without side draft, the chain holding the back gangs in position, and the weighting at the convex ends of the gangs

Fig. 5. (Right) Note the relative angles and positions of gangs. This is the same harrow shown in Fig. 4

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture

A Critical Study of the Hygroscopic Coefficient of Soil, A. N. Puri (Journal Agricultural Science [England], 15 (1925), No. 3, pp. 272-283, figs. 3).—Studies conducted at the Rothamsted Experimental Station on the hygroscopic coefficient of soil at 5 temperatures, ranging from 15 to 35.6 degrees Centigrade (59 to 96 degrees Fahrenheit) are reported.

It was found that the customary period of from 12 to 24 hours used by previous workers is much too short to give any approach to final values. At the lower temperatures, all except the very light soils continued to take up water almost indefinitely, and it was not possible to extrapolate to an approximate final value. These final values decreased with increasing temperature, but in the early stages the rate of moisture absorption increased with increasing temperature.

The conclusion is drawn that the hygroscopic coefficient cannot be satisfactorily determined even when the technique is refined considerably beyond that reasonably possible in routine determinations. This conclusion is supported by the results of vapor pressure determinations of moist soil and by a consideration of the manner in which colloidal material of a reticulate structure takes up water vapor. It is suggested that a measurement of the moisture content of soil in equilibriaum with an atmosphere of 50 per cent relative humidity should replace the hygroscopic coefficient. The proposed determination can be quickly and accurately made, and is only slightly affected by temperature changes. It has the further advantage in that it corresponds closely to a definite point on the vapor pressure curve, the point of inflection.

The Chemical Composition of Soil Colloids, W. O. Robinson and R. S. Holmes (U. S. Department Agricultural Bulletin 1311 (1924), pp. 42).—Studies are reported on the composition of soil colloidal matter which can be brought into a finely dispersed condition in water. Analyses are given of the colloidal matter isolated from 45 soils representing important agricultural types in the United States and covering wide ranges of composition, exclusive of peats and laterites.

The colloidal matter was found to be composed mainly of silica, alumina, iron oxide, and water, with smaller amounts of lime, magnesia, potash, soda, phosphorous, manganese, sulphur, chlorine, and organic matter. There was a rather wide variation in the proportions of these constituents present in different colloids, although a considerable number of the colloids showed an almost constant composition. In general, the sum of the lime, magnesia, potash, and soda was low when the silica was low and high when the silica was high. Silica and alumina usually varied inversely.

The colloidal matter from the soil and corresponding subsoil was much alike in composition. The composition of the colloidal matter differed from that of the total soil in being high in alumina, iron, water of combination, organic matter, magnesia, phosphorus, and sulphur, and lower in silica. There was the same general difference in composition between the colloidal matter and the coarser mineral particles that there was between the colloidal matter and the soil, but the difference was more pronounced. The part of colloidal matter which was most readily dispersed was fairly representative in composition of all that it was possible to isolate. In some cases, however, the colloidal matter first dispersed differed considerably from the small part that was obtained toward the end of the extraction process.

The extent of the leaching to which the colloids were exposed is considered to be probably the most important cause of the variations in their compositions. Other factors, such as composition of the parent material, character of the leaching, and enrichment, probably also produce variations. The present rainfall was not always a reliable indication of the extent to which leaching had taken place, although in general soil colloids developed in humid climates showed the greatest effects of leaching. Red or yellow colloids showed the effect of more profound leaching than gray or black colloids.

The colloidal matter of soils was found to be made up chiefly of the products of the chemical weathering of soil-forming minerals. It contained, however, small amounts of fine mineral fragments, and some colloids contained more of these mineral fragments than others. The colloidal matter behaved as a very intimate mixture and strongly resisted separation into fractions of different composition. It is considered probable that separate particles of different composition do not exist in the colloidal matter of soils.

The lime, soda, potash, magnesia, and silica were extracted more easily from soil colloids by water than the alumina and iron, although the colloidal matter held all of the constituents with great tenacity. Lime and soda were extracted somewhat more easily than potash and magnesia. Digestion with dilute acids removed the red or yellow colors from soil colloids. There were indications of two forms of iron in soil colloids—one a red or yellow hydrous iron oxide and the other some colorless combination, probably a silicate.

Stoichiometrical calculations showed that all the silica, alumina, iron, and water in the colloidal matter were not present in the proportion to form the more common hydrated silicates of alumina and iron, such as kaolinite and nontronite. It is considered possible, however, that some or a considerable part of these constituents may be present in compounds of the composition of such minerals as kaolinite, nontronite, halloysite, or pyrophyllite.

The Present Status of Subgrade Studies, A. C. Rose (U. S. Department Agriculture, Public Roads, 6 (1925), No. 7, pp. 137-162, figs. 12).—A review is presented of the progress of subgrade research.

It has been found that the quantity and character of the clay content of a soil in the United States seems in general to determine whether it will make a good or bad subgrade. The moisture equivalent percentage appears to be of critical value with reference to the bearing power of the subgrade soil. When wetted beyond this percentage, the bearing power seems to fall off rapidly.

There are indications that the moisture content rarely exceeds the moisture equivalent percentage at a depth below the surface of the soil sufficient to be removed from the influence of surface water and other forms of free water. There are also indications that by proper subgrade design it may be possible to control the moisture content of a subgrade soil to a maximum value approximately equal to the moisture equivalent percentage.

Construction methods which may be used to overcome the effect of bad subgrade soils are enumerated as (1) the use of coarse-grained soils for building fills over heavy clay soils, (2) the use of side ditches of special design, (3) the use of tile drains beside but not under the pavement, (4) the use of a granular subbase, (5) thickening of the pavement, and (6) the addition of steel reinforcement.

Some Further Observations on the Species Method of Differentiating Fæcal Organisms in Surface Waters in the Tropics, A. D. Stewart and V. G. Raju (Indian Journal Medical Research, 11 (1924), No. 4, pp. 1157-1162).—Studies are reported which showed that **B. coli communis** is a very common organism in human feces, forming 29 per cent of the fecal organisms present and 26 per cent of those in septic tank latrine effluents. It is distinctly rarer in cow manure, and forms only 12 per cent of the fecal bacilli. The **B. coli communis** is much rarer in waters which have received some natural purification, but is present in all waters subject to typical fecal pollution.

The numbers of **B. coli communis** isolated from stored water were in marked contrast to those obtained from human feces, in spite of the fact that several of the samples examined had only a short period of storage. **B. coli communis** formed only 8 per cent as against 29 per cent in human feces, 26 per cent in septic tank latrine effluents, and 20 per cent in typically polluted river water. **B. neapolitanus** formed 37 per cent as against 32 per cent in crude human feces and 28 per cent in latrine effluents. This is taken to indicate that this organism is not adversely affected by storage, and consequently is found in stored waters in equal or greater number than in freshly polluted waters or crude human feces.

B. coli communis was not found at all in any of the waters subjected to prolonged storage in spite of the fact that it was a predominating organism at the start. **B. coscoroba** formed only 3 per cent of the organisms isolated from human feces, whereas in the case of cow manure it formed 20 per cent.

The results of the examination of septic tank latrine effluents showed a close parallelism to those of human feces in important respects. These results are taken to indicate that the numerical proportion of the main fecal organisms is not materially altered in the course of the passage of the effluents through a septic tank. The storage and natural purification of polluted waters on the other hand caused certain important changes to take place in the fecal flora and tended to alter the relative proportion of the different varieties originally present.

The Six-Wheel Truck and the Pavement, L. W. Teller (U. S. Department Agriculture, Public Roads, 6 (1925), No. 8, pp. 165-168, 184, figs. 12).—Tests are reported which indicate definitely that the tensile stress set up in a concrete pavement by a six-wheel truck is only about half as great as the stress produced by a four-wheel truck of the same gross load. The tests also showed that the stress produced in the pavement by the six-wheel vehicles is a function of the load on the wheels and not of the axle spacing. This seems to be true for all spacings of the rear axles greater than 3 feet, there being some indication that when the wheels are closer together than 36 inches, the stress produced in the pavement may be increased.

It is also shown that under six-wheel as well as four-wheel trucks the maximum tensile stress occurs in the bottom of the slab, regardless of the axle spacing. Even though there is counterflexure of the pavement between the wheels, the tension developed in the top of the slab is of less magnitude than that developed in the bottom of the slab directly under the wheels. This latter tension,

therefore, is the critical stress for six-wheel as well as four-wheel vehicles. Loads passing over the pavement 21 inches from the edge were found to produce an average stress less than 50 per cent as great as that produced by the same loads passing 9 inches from the edge.

The maximum deformation of the concrete slab was found to occur along the edge under both four and six-wheel vehicles. When subjected to loads of varying magnitude applied at the same point, both the deflection and deformation of the slab were found to be proportional to the load.

Effects of Forest Fires on Land Clearing and Crop Production, M. J. Thompson (Minnesota Station Bulletin 220 (1925), pp. 3-23, figs. 12).—Experiments are reported which showed that the forest fire of October 12, 1918, at the Northeast Experiment Station occasioned a saving of 40 per cent in man labor in brushing, 16 per cent in logging, and 40 per cent in skidding and miscellaneous work. However, the burning of brush required 46 per cent more time.

The fire seemed more effective than four years of decay in reducing stumping costs. Stumps that were dead, partially decayed, and burned were cleared at a saving of 35.7 per cent in man labor and 36.7 per cent in horse labor as compared with stumps that were green when burned.

Post-fire clearing of green stumps was done at a saving at 23.1 per cent in man labor and 21.2 per cent in horse labor. Post-fire clearing of ripe dry stumps was done at a saving of 44.9 per cent in man labor. The principal saving in removing dry stumps as compared with green stumps was in explosive rather than in labor. Using 1914 price levels, post-fire clearing of all conditions of stumps was done at a saving of 55.17 per cent of pre-fire costs for both green and dry stumps.

Under very favorable conditions a light tractor showed a slight advantage over horses in speed of stumping, but both were about equal in completeness of work.

Land Clearing Practices in Minnesota, M. J. Thompson and A. J. Schwantes (Minnesota University Agricultural Extension Special Bulletin 97 (1925), pp. 12, figs. 3).—The results of a questionnaire relating to standard practices in connection with various land clearing operations in northern Minnesota are briefly presented. The questionnaire covered practically all phases of land clearing, and the data represent nearly 1,000 acres in eight representative counties of the cut-over district in the state.

It is shown that the average brushing crew consists of two men, and the axe is the most popular tool for cutting brush. The average number of man-hours required to brush an acre was found to be 32.4. It is considered questionable whether the advantages of cutting brush in the late summer to prevent sprouting back will justify this practice under ordinary farm conditions. It was found that sheep must be starved down to the pasture to do any real good from the standpoint of brush removal. Blasting may be done at least one-third cheaper when the soil is full of moisture than when it is dry.

In 40 per cent of the cases some mechanical means of stump removal, consisting of block and tackle, tractor, and horse-power stump pullers, was used to supplement explosives. The average total blasting cost per acre was $11.56, including both labor and materials, and the average estimated cost of stumping and burning an acre ready for the plow was $31.53. Over 39 per cent of the breaking plows used were of the 16-inch size, and 8 inches was the most popular depth of breaking.

Economic Rural Distribution of Electrical Energy by Galvanized Iron and Copper Lines with Ground Return [trans. title], G. Viel (Rev. Gen. Elect., 14 (1923), No. 8, pp. 253-259, figs 6).—The economics of power distribution for agricultural purposes where each consumer takes from 5 to 15 kilowatts are anaylzed.

The use of single-phase current at 10,000 volts with galvanized iron overhead wire and earth return is advocated. It is shown that with a single-phase line of about 4 millimeters in diameter of galvanized iron wire at 10,000 volts and 15 kilometers in length, 10 kilowatts can be transmitted with 4 per cent loss. The cost of a 3-phase line with copper conduits would be more than twice as much for the same conditions.

Prices are given for larger distribution schemes, together with a calculation for voltage and losses. It is shown that the voltage drop for the same current is from 8 to 13 times as great in iron wires as in copper wires, a great deal of the drop being due to skin effect.

Tests to determine potential gradient in the earth with a grounded return led to the conclusion than an earth return is quite safe if suitable earthing plates are used covered with from 10 to 12 centimeters of coke or charcoal moistened with an electrolyte and placed from 2 to 4 meters below ground level. The plates should also be joined to the line by an insulated conductor, and their number should be increased where bad earth is encountered. The surface of the earth should be covered with materials that are poor conductors wherever the plates cannot be buried deep enough, and such areas should be enclosed.

Tests on the inductive effect on telephone and telegraph wires showed that the induced currents were too small to have any disturbing effect. For low tension distribution it is considered preferable to have a metallic return, as an earth return would have too much resistance.

Ground Water Fluctuations at Kearney Park, California (Hilgardia [California Station], 1 (1925), No. 7, pp. 133-144, figs. 5).—Data from eight years' observations on the fluctuations of the ground water table in Kearney Vineyard are reported and discussed.

Many of the wells were found to show rather erratic fluctuations due to irrigation. The water table was found to reach a point nearest the surface during June, and during most of the year was well within the ideal root zone of plants. The feeding zone was found in reality to be the most restricted during the midsummer because of the position of the water table. It is considered probable that for the type of soil in the region and with the shallow depth to the ground water, water will rise to the surface by capillarity during the entire year. During that part of the year when the temperatures are the most favorable for high evaporation the water table is nearest the surface. There must necessarily be a rapid accumulation of alkali at the surface under these conditions.

The seasonal fluctuation of the water table was found to be between 5 and 6 feet, and the most rapid rise occurred during March and April. As the season progressed the rate of rise was much less than in the early spring. There was very little fluctuation during June, and the water table receded in July. There appeared to be little or no tendency toward an annual increase in the height of the water table.

The significance of these findings in connection with the design of drainage and irrigation systems is discussed.

Agricultural Engineering [Studies at the Iowa Station] (Iowa Station Report 1924, pp. 7-9).—Studies begun in 1914 to determine a satisfactory treatment for making silo walls impervious have shown that bitumen or asphalt applied in a way so as to insure a good bond is the most satisfactory method. All attempts to use plaster coats of various kinds have been generally unsuccessful at the end of ten years.

Studies of silo capacities have shown that the storage capacity of silos evidently varies widely from year to year, due primarily to differences in the water content of the silage and to a less extent to the weight of the grain.

Studies of the economy of operation of farm implements, as revealed by draft, have shown that extreme sharpness of the plowshare has little influence on the draft of the plow in mellow soil. However, the draft was materially increased when a dull share was used in alfalfa sod. The average draft of a 14-inch plow working 5 inches deep with a sharp share was 740 pounds, while with the edge dulled to ⅛-inch thickness it was increased to 881 pounds. The sharpness of the share greatly influenced the ability of the plow to penetrate hard soil.

An experiment on masonry arch barn construction, which involved the design, construction, and testing to destruction of a 36-foot reinforced concrete and clay block arch with a rise of 24 feet 7 inches, showed that the arch as designed was much stronger than required. The breaking stress required to cause failure was equivalent to the pressure created by a wind velocity of 160 miles per hour. These results are taken to indicate the possibility and practicability of building a barn of masonry material.

Experiments with L-shaped concrete blocks showed that a block with an 8- by 16-inch face could be made in a gang mold at a cost of 3.5 cents for material and 1.5 cents for labor.

A continuation of the studies of the durability of prepared roofing indicated that exposure to the sun is one of the most important deteriorating factors.

Brief data on the standardization of farm machinery and on a study of the horse as a motor are also included.

Press Work in Agricultural Machinery Plants, C. C. Hermann (Machinery, 32 (1925), No. 2, pp. 120-122, figs. 6).—A description is given of the drawing dies used in the production of a gasoline tank and a bowl for a cream separator.

Tile Drainage of Farm Lands, L. G. Heimpel and F. G. North (Quebec Department Agricultural Bulletin 89 (1925), pp. 63, figs. 49). —A large amount of practical information on the planning and installation of tile drains is presented, which is based upon the available knowledge of soil hydraulics.

Trench Silos in Minnesota, A. Boss, H. B. White, and A. J. Schwantes (Minnesota University Agricultural Extension Special Bulletin 100 (1925), pp. 7, figs. 5).—Practical information on the planning and construction of trench silos in Minnesota is presented.

Some Hints on Installing and Operating Domestic Oil Burners, C. H. Chalmers (Journal American Society Heating and Ventilating Engineers, 31 (1925), No. 10, pp. 471-476, fig. 1).—Practical information on the subject is presented.

A Study of the Factors Involved in Ensilage Cutter Design

(Continued from page 87)

Very Small Cutters Uneconomical. We believe that cutters smaller than 12 inches are as a general rule uneconomical to operate. They are frequently operated at excessive speeds in order to get the desired capacity. This means more power per ton of corn cut and greater wear and tear on the machine. Also they are harder to feed due to the table being so narrow.

Author's Note: After final checking a few minor changes were made. Tests 11 to 16 in Table I were originally reported as for a Belle City machine. This machine has been bought by the J. I. Case Threshing Machine Company. A complete set of tests for the Rowell (Tests 28 to 31, Table I) equipped with a 7-inch pipe have been substituted for those originally reported for the machine equipped with a 6½-inch pipe, as the 7-inch pipe has been adopted as standard.

News of the Annual Meeting

Tahoe Tavern — Lake Tahoe — California

Meeting Dates, June 23-26, 1926 **Inspection Trips, June 28—July 1, 1926**

Description of Inspection Trip Number One

Visit to Hydroelectric Developments in Sierra Nevadas

VIEWING wonderful mountain scenery, interesting hydroelectric developments and irrigated orchards in the foothills is on the program for the first day of the inspection trips.

The start will be made from the Tahoe Tavern early Monday morning (June 28), via Southern Pacific train, along the banks of the Truckee River to Truckee, and thence to a point in the vicinity of the Pacific Gas and Electric Company's Lake Spaulding dam, where automobiles will be waiting and we will become the guests of the Pacific Gas and Electric Company. On reaching this point we will travel over the summit of the Sierra Nevadas and through a region of historical romance handed down from the days when the emigrant trail was nothing more than a mere landmark.

The Spaulding Drum Development of the Pacific Gas and Electric Company finds its main sources of water supply in a cluster of artificial lakes, twenty-one in number, and with a storage capacity of 115,893 acre-feet. While at the Spaulding Dam, which is 275 feet in height, the party will view what are probably two of the most unique power houses in California, if not the United States. One plant is located in solid rock alongside a tunnel which carries water from the Lake Spaulding dam to the lowlands below. Via automobile the party will be conveyed to the Drum power house, a hydroelectric power plant of 50,268 horsepower capacity, where lunch will be served. From this point the party will continue to Auburn, visiting the Wise and Halsey power houses enroute. After dinner, which will be at Auburn, the party will be taken by automobile to Sacramento.

The region to be covered is indeed an interesting one, for it is dotted with landmarks vividly reminiscent of the days when the hardy pioneers made their hazardous journey across the plains in quest of the red gold that lay buried in the foothills. From the Sierra Nevada summit, on the Truckee side, one looks down upon the placid waters of Donner Lake, whose name recalls the terrible tragedy of the winter of '46. Below the summit lies Emigrant Gap that marks the spot where the emigrant trail crossed the ridge into Bear Valley and on to the camps of Nevada City and Grass Valley, and down whose precipitous slopes, so the story runs, the ox teams were let down by ropes. More than one of the lakes that form this South Yuba system has historical value. Meadow Lake, for instance, was once the site of a flourishing community in the days of the rush for gold, with hotels, banks, gambling halls, all that was part and parcel of the feverish life of the pioneer times. That community has long since vanished from the surface of the earth, but the lake remains. Lake Fordyce, another relic of the early mining days, is now the parent reservoir of the system; the first dam was built there in 1873. At the west end of the cluster there lies another lake that recalls memories of early days, Lake Spaulding, a noble sheet of water below Emigrant Gap and at the edge of Bear Valley, fed by the South Yuba River in its tortuous course westward.

The interesting feature of this great hydroelectric development and particularly as it relates to agriculture, is the fact that the stored water in these lakes and reservoirs is released for the operation of a chain of five hydroelectric plants and then flows undiminished through irrigation ditches to a great, rich agricultural section of California. The water irrigates the land that grows the fruits and farm products, and the energy generated by this same water is used by the farmers and their wives for the operation of electrical appliances, which add prosperity, comfort and convenience to their lives.

Busy with Annual Meeting Plans

THE executive committee of the Pacific Coast Section of the American Society of Agricultural Engineers met in Berkeley, February 5, to discuss plans for the 1926 annual meeting to be held at Lake Tahoe, California, June 23 to 26.

It was the unanimous opinion of the members of the committee attending the meeting that the routing of the special train, it is proposed to run from Chicago, over the Chicago & Northwestern, Union Pacific, and Southern Pacific railroads was the most desirable. All possible routings were discussed but the shortest time, greater dependability and comfort, and the fact that those attending could have their choice of return routings were factors in the decision.

Reports on annual meeting arrangements were heard from committees on transportation, local arrangements, inspection trips, finance, publicity, and post-convention trips and activities.

The members of the Pacific Coast Section are organized into an effective working unit for developing plans in connection with all phases of the annual meeting, inspection trips, and return trips for those attending the meeting from the East; in fact, the preparations that are being made are unusual in their thoroughness and attention to all possible features contributing to the instruction and entertainment of those attending the annual meeting.

The annual meetings of the American Society of Agricultural Engineers during the past few years have been outstanding successes from the standpoint of arrangement and quality of the programs presented. The reason for this is largely the result of a fortunate selection of meetings committees. A noteworthy fact about these meetings is that each year's meeting has been a conspicuous improvement over that of the preceding year. The remarkable record that has already been set in A.S.A.E. annual meetings will be equaled again this year in the meeting at Lake Tahoe. Due to an abundance of new material from research and development work, there is every indication that this year's program will be the best ever offered.

A. S. A. E. and Allied Activities

The National Farm Homes Conference

THE National Farm Homes Conference, sponsored by the Farm Structures Division of the American Society of Agricultural Engineers and held in Chicago, February 18 and 19, was an oustanding success and greatly exceeded the expectations of those having the program in charge. Unquestionably, it is one of the most important movements that has been inaugurated in some time, and a great deal of support and encouragement has been given the Society in this endeavor.

The complete proceedings of the conference will appear in the April issue of AGRICULTURAL ENGINEERING, which will be published as a special better farm homes issue. A special price of $1.00 per copy will be charged for copies of the April issue, although members of the Society and regular subscribers of the Journal will receive their regular copies without extra charge.

Tractor Meeting Postponed

THE cooperative tractor meeting between the American Society of Agricultural Engineers and the Society of Automotive Engineers that was to have been held in Chicago, March 25 and 26, as announced in the February issue of AGRICULTURAL ENGINEERING, has been postponed. The reason for the postponement is due to the conditions prevailing in the tractor industry at the present time. Never in the history of the industry have engineers been so busy with development work as they are at the present time. From a survey made of this situation it was thought best to postpone the holding of the meeting until a time when engineers would find it more convenient to attend the meeting.

While both organizations sponsoring the meeting are anxious to be of assistance to engineers in their development work, it would seem that engineers could be helped most at the present time by postponing the meeting until after the rush season is over. While no definite date has yet been decided upon for holding the postponed meeting, there is a possibility that it will be held in connection with the fall meeting of the Farm Power and Machinery Division of the American Society of Agricultural Engineers which is usually held the first week in December.

Ives Hall Dedicated

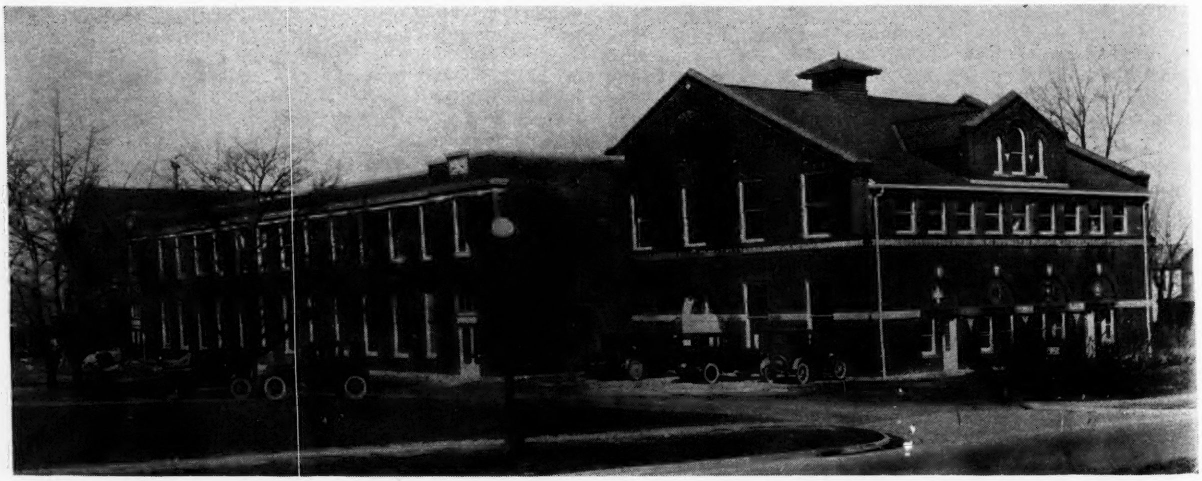
THE dedication of Ives Hall, the new agricultural engineering building at Ohio State University, took place on February 3. In spite of the fact that the dedication was held during Farmers Week, the large lecture room of the building was filled to overflowing with a representative group of members of the University faculty, farmers, students, and agricultural engineers.

The dedication program was a most impressive one, and particularly fitting the occasion. It was opened by Dean Alfred Vivian of the college of agriculture, who paid a splendid tribute to Frederick Walter Ives and his outstanding accomplishments in establishing agricultural engineering as one of the leading departments in the college of agriculture. He also praised the agricultural engineering staff of the university for the work it has done and is doing.

The American Society of Agricultural Engineers was represented at the dedication by Secretary Raymond Olney, who delivered a brief address befitting the occasion. He pointed out that Ives Hall represented the net result of the recognition that had been accorded agricultural engineering at Ohio State University and in the state, and that no more appropriate monument could have been erected to commemorate the life and work of the late Prof. Ives, all the more appropriate because it so largely represented the thought and cherished plans of Prof. Ives himself.

H. C. Ramsower, director of agricultural extension at Ohio State University and first head of the department of agricultural engineering at that institution, reviewed the growth and development of agricultural engineering at the University. He praised in highest terms the success of Prof. Ives as teacher and administrator.

Representing the agricultural equipment industry, as one of the leading industries allied to the agricultural engineering profession, Finley P. Mount, president of Advance-Rumely Company and a past president of the National Association of Farm Equipment Manufacturers, delivered an address on the relationship of agricultural engineering with agriculture and the manufacturing industry. He pointed out some of the problems with which agriculture is concerned at the present time and how the agricultural engineer and the manufacturing industry fits in with the solution of these problems.



This is Ives Hall, the new agricultural engineering building at the Ohio State University, dedicated February 3, 1926, in honor of the late Frederick Walter Ives, one of the recognized leaders of the agricultural engineering profession

Agricultural engineering from the viewpoint of the farmer was presented in a very interesting and effective manner by E. J. Riggs, a former student of the University and at present a member of the Ohio legislature.

Ives Hall was formally dedicated by Harry Caton, a member of the Board of Trustees of the University, and grand master of the Ohio State Grange, who in a brief address painted a very interesting picture of the place of agricultural engineering in the life and operations on the farm and in the home of the future.

The dedication exercises were followed by an inspection of the building and later by a complimentary luncheon tendered the speakers.

The dedication exercises have set a new milestone in the growth and progress of agricultural engineering at Ohio State University. The department of agricultural engineering, which is at present housed by Ives Hall, already has an enviable record of achievement and service to its credit, but this work is destined to develop into still larger achievement and an influence that will extend beyond the confines of the state to the nation and the world at large.

Pacific Coast Section Meeting

"THE A.S.A.E. and Reclamation" was the main subject discussed at the meeting, December 18, of the Pacific Coast Section of the American Society of Agricultural Engineers. Forty-seven men all interested in some phase of reclamation attended this meeting, twenty-five being members of the Society.

The paper prepared by Major O. V. P. Stout, which appeared elswhere in the February issue of AGRICULTURAL ENGINEERING, formed the basis for the discussion. A. E. Backman, of the Federal Land Bank, Berkeley, read a formal discussion of Major Stout's paper, which had been prepared by W. R. Parkhill, engineering appraiser for the Bank.

J. C. Boyd, chairman of the Sacramento Section of the American Society of Civil Engineers, extended the greetings of his organization and stated that in his opinion Major Stout had resented a splendid basis for cooperation between the two societies.

Edward Hyatt, Jr., chief of the division of water rights, California State Department of Public Works, said, "It is my opinion that the development of and the need for such a society as the American Society of Agricultural Engineers is an instance of the great specilization which is characteristic of modern civilization. In early human existence man's total energies were devoted to the procurement of absolute necessities and there was little, if any, margin between production and necessities. With the growth of knowledge and the utilization of natural resources, production developed a margin over necessities, thus creating wealth. In modern civilzation due to an extensive use of natural sources of power and other resources, this margin has greatly increased and all fields of activity have been intensively studied by specialists. The whole trend of modern civilization is toward specialization. Further advance in any given science can be made only by specialization, since to proceed beyond the present knowledge a man must devote his entire time to a particular branch of a subject."

Practically everyone attending the meeting entered into the discussion. The concensus of opinion was decidedly in favor of the agricultural engineer taking an active part in the reclamation or development of lands along the lines laid down by Major Stout.

A meeting of the general committee in charge of the 1926 annual meeting of the Society was held in the morning and reports made at the dinner and evening meetings of the Section. Everyone who has been requested to cooperate toward making this meeting a success is responding in a most gratifying manner. Many details of local arrangements, entertainment, inspection trips, transportation, post-convention activities, etc., were discussed and provided for. P. E. Holt, chairman of the finance committee, promised to raise the money for a good healthy budget. Special letters from President F. A. Wirt and the North Atlantic Section were read and much appreciated.

Chairman Frank Adams appointed a special committee, before the afternoon session, to prepare, in a short statement, a policy on reclamation for the American Society of Agricultural Engineers. This committee consisted of W. W. McLaughlin, S. H. Beckett and W. W. Weir. They made a report at the evening session but asked for an extension of time for the purpose of better preparing the statements. It was proposed that this policy be presented to the Society at the next annual meeting.

The "Southwest" Heard From

Dear Mr. Olney:

THE Southwest Section welcomes your request for a report on section activities, even though at first glance it seems that the Southwest Section has no activities to report. But let's look at the situation.

At the meeting held for the purpose of ascertaining the feeling existing regarding the formation of a Southwest Section, eight active members were present besides several men who would make good members.

Our petition for organization required the signatures of ten members, and actually carried fifteen signatures. The membership at this date totals nineteen. Our territory embraces the states of Arkansas, Louisiana, Texas, New Mexico, and Oklahoma. You will readily see that we have room to grow; the question is how to utilize all this space to prevent its being a detriment. It would necessitate considerable expenditure of time and money to obtain a picture such as you published last month of the North Atlantic Section because of the one factor, distance, so I'm going to do what occurs to me as the next best thing, that is, list the names and addresses of each member. Maybe some can visualize a composite picture of the bunch. Here they are: D. G. Carter, H. T. Barr, Ed Doran, U. S. Allison, S. S. Graham, F. R. Jones, H. P. Smith, M. R. Bentley, Dan Scoates, R. G. Hemphill, J. L. Saunders, G. H. Alford, M. B. Barnett, H. R. Herndon, R. W. Baird, L. E. Hazen, W. H. McPheeters, G. E. Martin, and W. E. Stanford. Texas has the largest representation and New Mexico the smallest. The Southwest Section will progress according to the goodwill and initiative of its individual members.

A few of us foregathered recently in Oklahoma City during the Drainage Congress, at which meeting S. H. McCrory was present.

Dan Scoates gives the Southwest Section considerable credit for linking up the Texas experiment station with a Purnell project in soil erosion, therefore, we have not lived in vain. If the section comes in 100 per cent we hope to get together along about May and discuss some things worth while. Cooperation is the thing.

G. E. MARTIN

Secretary, Southwest Section

Activities of Student Branches

University of Saskatchewan

THE student branch of the American Society of Agricultural Engineers at the University of Saskatchewan is making an excellent showing in its efforts to promote agricultural engineering in the Province of Saskatchewan. The intense earnestness and sincerity of purpose of this branch is evidenced in the following letter addressed to A.S.A.E. national headquarters by its president, Harry Miller:

"As our agricultural engineering society is now in its third year of successful existence, we thought you might be interested in learning about our organization and its problems.

"Three years ago Prof. E. A. Hardy called together all the students specializing in agricultural engineering, and explained to them the possibilities of the agricultural-engineering profession and told them about the American Society of Agricultural Engineers. A branch was organized immediately and a program of work arranged. Since then meetings have been held regularly, at which we discuss our problems.

"This being a new country we have problems peculiar to a new country. Most of this area has been settled within the last twenty years. The problem immediately before the settler was to bring the land into cultivation. He erected only temporary buildings. Now the old buildings are being

replaced by permanent ones. This brings two problems to be solved at once, the buildings themselves and the planning of the farmstead. While there is considerable material available on the former, very little is available on the latter. Papers on farmstead planning have been given and discussed at the meetings of our branch. As agricultural engineers we hope to be of use in this way to the agricultural industry.

"Associated with the problem of building is that of equipment. Also electricity if it can be cheaply produced is a very desirable power for the farm, and the wind offers a very promising source for generating electricity. We intend to do some work on this subject in the immediate future to determine its feasibility.

"Since this is more of a grain farming country, the requirement for farm power is very seasonal, and consequently the problem is a very vital one. Obviously it is poor economy for a farmer to keep a sufficient number of horses to carry him easily over the peak loads. The farm tractor seems to be the most feasible thing to carry the farmer over the peaks as well as to serve as a standby the rest of the time. The practicability of the tractor has been discussed by our branch and we are very proud to say that W. C. Wood, one of our members, has won the first prize in the essay competition of the J. I. Case Threshing Machine Company on this subject. Mr. Wood has investigated the problem of power farming very thoroughly, and I hope that everyone who is interested in power farming will have the pleasure of reading Mr. Wood's essay.

"The membership of our branch is now eleven. The students of other branches of agriculture are showing a very keen interest in our work. We hope to interest more men in this field."

Wisconsin Has 100 Per Cent Membership

THE student branch of the Society at the University of Wisconsin has gotten under way early in the year and a very enjoyable and profitable year is anticipated. The branch has a real achievement to its credit in that they can boast of a 100-per-cent membership for the first time in the history of the branch, that is, all the students majoring in agricultural engineering at the University of Wisconsin are now members of the student branch and, what is more, their dues for 1925 are paid.

New A.S.A.E. Members

Irvin H. Althouse, engineer, Terra Bella Irrigation District and Vandalia Irrigation District, and consulting engineer, Irrigation Equipment Engineering Company, Terra Bella, California.

Herbert S. Hinrichs, field engineer, engineering experiment station, Kansas State Agricultural College, Larned, Kansas.

George Frederick Krogh, technical draftsman and assistant in drainage, University of Minnesota, Department of Agriculture, St. Paul, Minnesota.

Dr. George Kuehne, professor of agricultural engineering, University of the State of Bavaria, Muenchen (Munich), Germany.

Paul C. McGrew, junior drainage engineer, division of agricultural engineering, University Farm, St. Paul, Minnesota.

Emory T. Miller, mechanical engineer, Manhattan Rubber Manufacturing Company, Passaic, New Jersey.

Wallace M. Murdock, Ford Motor Company of Canada, Ltd., Toronto, Canada.

Philip Schuyler, engineering editor, "Western Construction News," 24 California Street, San Francisco, California.

Frank J. Veihmeyer, associate irrigation engineer, College of Agriculture, Davis, California.

Norman T. Wilcox, sales development and rate studies, Stone & Webster, Inc., Boston, Massachusetts.

Carol W. Wright, superintendent, Stanford Vina Ranch Irrigation Co., Vina, Tehama County, California.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the February issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Herbert M. Bonnell, sales manager, Milwaukee Air Power Pump Company, 10 Keefe Avenue, Milwaukee, Wisconsin.

Willard Cowles Brown, commercial engineer, National Lamp Works of General Electric Company, Nela Park, Cleveland, Ohio.

W. W. Cameron, experimental engineer, La Crosse Plow Company, La Crosse, Wisconsin.

Ralph M. Gray, engineer, Table Mountain Irrigation District and Table Mountain Ranch, Oroville, California.

Harry J. Hirshheimer, president and general manager, La Crosse Plow Company, La Crosse, Wisconsin.

George C. D. Lenth, secretary, Clay Products Association, Chicago, Illinois.

Ruby M. Loper, extension work, department of agricultural engineering, University of Nebraska, Lincoln, Nebraska.

Carl R. Olson, assistant county surveyor and assistant city engineer, Urbana, Illinois.

Lorne S. Robertson, Louden Machinery Company, Yonkers, New York.

Transfer of Grade

J. I. Mutchler, instructor, department of agricultural engineering, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. (From Student to Junior.)

A Correction

THE name of Howard C. Miller, agricultural engineer for the Utica Gas & Electric Company, Utica, New York, listed among the new A.S.A.E. members on page 68 of the February issue of AGRICULTURAL ENGINEERING, was incorrect as given. The correct name is Howard C. Fuller.

Employment Bulletin

This service, conducted by the American Society of Agricultural Engineers, appears regularly in each issue of Agricultural Engineering. Members of the Society in good standing will be listed in the published notices of the "Men Available" section. Non-members as well as members, are privileged to use the "Positions Available" section. Copy for notices should be in the Secretary's hands by the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. No charge will be made for this service.

Men Available

AGRICULTURAL ENGINEER, married, age 29, 1922 graduate of Iowa State College in agricultural engineering, now assistant engineer in construction department of International Railways of Central America, desires position where permanent residence is possible, preferably experimental or production work, or management of reclamation project or large ranch. Ten years experience in general farming with power equipment, experimental and teaching work, and construction work. Can speak Spanish, also some French and German. MA-130.

Positions Open

SALES ENGINEERS WANTED: One of the largest bearing manufacturers in America can use the services of two good sales engineers. Men with an engineering education and sales experience in farm tractor and implement field are preferred. They should have designing ability so that they can be of service to tractor design. Those experienced in the farm-implement and tractor design will be shown preference. Write fully giving all data as to experience, education and salary expected.

AGRICULTURAL ENGINEER wanted for sales position in the East. Age 27 to 40. Must be in good health. In application state whether married or single, age, height, weight, religion, color of hair and eyes, also where employed for last three years and state experience, if any. Salary, expenses and commission. Address Louden Machinery Co., Albany, N. Y.

YOUNG MAN, preferably with agricultural college training, wanted to do research and publicity work. He must be familiar with agricultural problems, use of modern farm equipment, and have some ability to write articles. PO-113.

YOUNG MAN qualified to act as secretary or assistant to sales manager is wanted by a large farm-equipment concern in Illinois. PO-115.

FACTORY SUPERINTENDENT with foundry experience wanted by farmer-equipment manufacturer in Ohio. PO-114.